Official Bulletin
Graduate Studies
2012–2014

Arts, Sciences & Engineering
School of Arts and Sciences
Edmund A. Hajim School of Engineering and Applied Sciences
Eastman School of Music
School of Medicine and Dentistry
School of Nursing
William E. Simon Graduate School of Business Administration
Margaret Warner Graduate School of Education and Human Development

The bulletin was prepared in the spring of 2012. Provisions of this publication are not to be regarded as an irrevocable contract between the student and the University. The University reserves the right to make changes in its course offerings, degree requirements, regulations and procedures, and fees and expenses as educational and financial considerations require.

Information in this bulletin does not apply to the MD Program in the School of Medicine and Dentistry.

The University of Rochester values diversity and is committed to equal opportunity for persons regardless of age, color, disability, ethnicity, gender identity or expression, genetic information, marital status, military/veteran status, national origin, race, religion/creed, sex, sexual orientation or any other status protected by law. Further, the University complies with all applicable non-discrimination laws in the administration of its policies, admissions, employment, and access to and treatment in University programs and activities. Questions on compliance should be directed to the particular school or department and/or to the University’s Equal Opportunity Coordinator, University of Rochester, P.O. Box 270039, Rochester, New York 14627-0039.
Contents

Publications about Graduate Programs .......................................................... 4
Graduate Studies Calendar, 2012–2014 .......................................................... 6
University Map ......................................................................................... 8
Graduate Education at the University of Rochester ..................................... 11
Graduate Student Life ............................................................................... 12
   Including housing, health care services, International Services Office, security
Financial Information .................................................................................. 17
   Including tuition and fees, financial aid, and loan programs
Graduate Degrees ....................................................................................... 20
Regulations and University Policies Concerning Graduate Study .............. 23
   Including registration, grades, disciplinary procedures, degree requirements
Arts, Sciences & Engineering ..................................................................... 47
   School of Arts and Sciences .................................................................. 49
      Edmund A. Hajim School of Engineering and Applied Sciences .......... 115
Eastman School of Music ........................................................................... 159
School of Medicine and Dentistry ............................................................. 165
School of Nursing ..................................................................................... 207
William E. Simon Graduate School of Business Administration .............. 233
Margaret Warner Graduate School of Education and Human Development 239
Inventory of Registered Programs .............................................................. 251
University Administration ......................................................................... 256
Index ........................................................................................................ 257
## Graduate Course Numbering System

<table>
<thead>
<tr>
<th>400–489</th>
<th>Master's first-year-level courses</th>
</tr>
</thead>
<tbody>
<tr>
<td>490–499</td>
<td>Master's-level reading and research courses</td>
</tr>
<tr>
<td>500–599</td>
<td>Advanced or specialized graduate courses and research; usually for doctoral-level students only</td>
</tr>
<tr>
<td>890</td>
<td>Master's summer registration in residence (not used by Arts, Sciences &amp; Engineering)</td>
</tr>
<tr>
<td>895</td>
<td>Continuation of master's enrollment</td>
</tr>
<tr>
<td>897</td>
<td>Master's full-time enrollment status</td>
</tr>
<tr>
<td>898</td>
<td>Master's part-time enrollment status</td>
</tr>
<tr>
<td>899</td>
<td>Master's dissertation full-time enrollment</td>
</tr>
<tr>
<td>985</td>
<td>Leaves of absence</td>
</tr>
<tr>
<td>990</td>
<td>Doctoral summer registration in residence (not used by Arts, Sciences &amp; Engineering)</td>
</tr>
<tr>
<td>995</td>
<td>Continuation of doctoral enrollment</td>
</tr>
<tr>
<td>997</td>
<td>Doctoral full-time enrollment status</td>
</tr>
<tr>
<td>998</td>
<td>Doctoral part-time enrollment status</td>
</tr>
<tr>
<td>999</td>
<td>Doctoral dissertation full-time enrollment</td>
</tr>
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</table>
# Publications about Graduate Programs at the University of Rochester

Most colleges and schools of the University publish brochures or Official Bulletins listing faculty, courses, and degree requirements. In addition, many departments offering graduate programs publish detailed brochures about their courses of study, faculty members, facilities, scholarships, etc. Most graduate programs have valuable information on their departmental websites.

Requests for departmental brochures and applications should be made to the following:

<table>
<thead>
<tr>
<th>School of Arts and Sciences</th>
<th>Departmental/Program brochures and online applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office of Graduate Studies</td>
<td>University of Rochester</td>
</tr>
<tr>
<td>218 Lattimore Hall</td>
<td>P.O. Box 270401</td>
</tr>
<tr>
<td>Rochester, New York 14627-0401</td>
<td>Email: <a href="mailto:graduate.admissions@rochester.edu">graduate.admissions@rochester.edu</a></td>
</tr>
<tr>
<td><a href="http://www.rochester.edu/college/sas">www.rochester.edu/college/sas</a></td>
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<thead>
<tr>
<th>Edmund A. Hajim School of Engineering and Applied Sciences</th>
<th>Departmental/Program brochures and online applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Institute of Optics brochure</td>
<td></td>
</tr>
<tr>
<td>Office of Graduate Studies</td>
<td>University of Rochester</td>
</tr>
<tr>
<td>218 Lattimore Hall</td>
<td>P.O. Box 270401</td>
</tr>
<tr>
<td>Rochester, New York 14627-0401</td>
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<table>
<thead>
<tr>
<th>Eastman School of Music</th>
<th>Official Bulletin</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Graduate and undergraduate)</td>
<td></td>
</tr>
<tr>
<td>Associate Dean of Admissions</td>
<td>Eastman School of Music</td>
</tr>
<tr>
<td>26 Gibbs Street</td>
<td>P.O. Box 601A</td>
</tr>
<tr>
<td>Rochester, New York 14604-2599</td>
<td>Email: <a href="mailto:gradadm@urmc.rochester.edu">gradadm@urmc.rochester.edu</a></td>
</tr>
<tr>
<td><a href="http://www.esm.rochester.edu/admissions">www.esm.rochester.edu/admissions</a></td>
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<thead>
<tr>
<th>School of Medicine and Dentistry</th>
<th>Graduate Education in the Biomedical Sciences brochure</th>
</tr>
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<tbody>
<tr>
<td>Departmental/Program brochures</td>
<td></td>
</tr>
<tr>
<td>Senior Associate Dean for Graduate Education</td>
<td>University of Rochester Medical Center</td>
</tr>
<tr>
<td>School of Medicine and Dentistry</td>
<td>601 Elmwood Avenue, Box 316</td>
</tr>
<tr>
<td>University of Rochester Medical Center</td>
<td>Rochester, New York 14642-0001</td>
</tr>
<tr>
<td>Email: <a href="mailto:gradadm@urmc.rochester.edu">gradadm@urmc.rochester.edu</a></td>
<td></td>
</tr>
</tbody>
</table>

| Office of Graduate Studies                                 | University of Rochester                                 |
| 218 Lattimore Hall                                        | P.O. Box 270401                                         |
| Rochester, New York 14627-0401                            | Email: graduate.admissions@rochester.edu               |
| www.rochester.edu/college/sas                             |                                                        |

<table>
<thead>
<tr>
<th>School of Medicine and Dentistry</th>
<th>University of Rochester</th>
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<tbody>
<tr>
<td>School of Medicine and Dentistry</td>
<td>Director of Admissions</td>
</tr>
<tr>
<td>University of Rochester Medical Center</td>
<td>Elmwood Avenue, Box 601A</td>
</tr>
<tr>
<td>Rochester, New York 14642-0001</td>
<td>Email: <a href="mailto:mdadmish@urmc.rochester.edu">mdadmish@urmc.rochester.edu</a></td>
</tr>
<tr>
<td>AMCAS: <a href="http://www.aamc.org">www.aamc.org</a></td>
<td></td>
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<table>
<thead>
<tr>
<th>Official Bulletin</th>
<th>University of Rochester</th>
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<tbody>
<tr>
<td>MD and MD/PhD programs</td>
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<tr>
<td>University of Rochester</td>
<td></td>
</tr>
<tr>
<td>School of Medicine and Dentistry</td>
<td></td>
</tr>
<tr>
<td>Director of Admissions</td>
<td>Elmwood Avenue, Box 601A</td>
</tr>
<tr>
<td>Rochester, New York 14642-0001</td>
<td>Email: <a href="mailto:mdadmish@urmc.rochester.edu">mdadmish@urmc.rochester.edu</a></td>
</tr>
<tr>
<td>AMCAS: <a href="http://www.aamc.org">www.aamc.org</a></td>
<td></td>
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</tbody>
</table>
| School of Nursing | Office of Student Affairs  
| School of Nursing | 601 Elmwood Avenue, Box SON  
| School of Nursing | Rochester, New York 14642-0001  
| | (585) 275-2375  
| www.son.rochester.edu |  |
| William E. Simon Graduate School of Business Administration | Admissions Office  
| William E. Simon Graduate School of Business Administration | 305 Schlegel Hall  
| University of Rochester | P.O. Box 270107  
| Rochester, New York 14627-0107 | (585) 275-3533  
| Email: admissions@simon.rochester.edu or emba@simon.rochester.edu |  |
| PhD program | PhD Office  
| William E. Simon Graduate School of Business Administration | 4345 Carol Simon Hall  
| University of Rochester | P.O. Box 270100  
| Rochester, New York 14627-0100 | (585) 275-2959  
| Email: phdoffice@simon.rochester.edu |  |
| Margaret Warner Graduate School of Education and Human Development | Admissions Office  
| Margaret Warner Graduate School of Education and Human Development | Dewey Hall (LeChase Hall after January 2013)  
| University of Rochester | P.O. 270425  
| Rochester, New York 14627-0425 | (585) 275-3950  
| Email: admissions@warner.rochester.edu |  
| www.warner.rochester.edu |  |
### 2012–2014 Calendar*

This calendar is prepared far in advance of publication. Some dates may change. For specific degree program deadlines (i.e., application deadlines, qualifying exam dates, dissertation deadlines), check with department and/or school graduate studies offices.

<table>
<thead>
<tr>
<th>Fall Semester 2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>August 30</td>
</tr>
<tr>
<td>October 8</td>
</tr>
<tr>
<td>December 22</td>
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</table>

<table>
<thead>
<tr>
<th>Spring Semester 2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>January 16</td>
</tr>
<tr>
<td>January 21</td>
</tr>
<tr>
<td>March 9</td>
</tr>
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<table>
<thead>
<tr>
<th>Fall Semester 2013</th>
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</thead>
<tbody>
<tr>
<td>September 3</td>
</tr>
<tr>
<td>October 7</td>
</tr>
<tr>
<td>November 27</td>
</tr>
<tr>
<td>December 22</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spring Semester 2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>January 15</td>
</tr>
<tr>
<td>January 20</td>
</tr>
<tr>
<td>March 8</td>
</tr>
<tr>
<td>May 16–18</td>
</tr>
</tbody>
</table>

* These dates do not apply to the William E. Simon Graduate School of Business Administration, which operates on a quarter-system calendar (www.simon.rochester.edu), or to the Eastman School of Music (www.rochester.edu/eastman).
Building Key by Number

1. Rush Rhees Library
2. Morey Hall
   Eastman Kodak
   Colonnade
3. Lattimore Hall
4. Strong Auditorium
5. Schlegel Hall
6. James S. Gleason Hall
7. Dewey Hall
8. Carol G. Simon Hall
9. Hoyt Hall
10. Bausch & Lomb Hall
11. Meliora Hall
12. Harkness Hall
13. Gavett Hall
14. Taylor Hall
15. Hopeman Engineering Bldg.
16. N.Y. State Center for Advanced Technology
17. Wilmot Bldg.
18. Robert B. Goergen Hall for Biomedical Engineering and Optics
   Carlson Science and Engineering Library
20. Hylan Bldg.
21. Hutchison Hall
   Hubbard Auditorium
   Lander Auditorium
22. Wallis Hall
   Admissions Office
   University Administration Offices
23. Interfaith Chapel
24. Todd Union
25. Delta Kappa Epsilon
26. Alpha Delta Phi
27. Theta Chi
28. Psi Upsilon
29. Community Learning Center (CLC)
30. Sigma Alpha Mu
31. Sigma Chi
32. Medieval House (Delta Upsilon)
33. Drama House
34. Burton Hall
35. Lovejoy Hall
36. Tieman Hall
37. Gilbert Hall
38. Hoeing Hall
39. Crosby Hall
40. Wilson Commons
41. Frederick Douglass Bldg.
   Bookstore
   Dining Center
   The Meliora
42. Robert B. Goergen Athletic Center
   Alexander Palestra
   Edmund A. Hajim
   Alumni Gymnasium
   Field House
   Pool and courts
   Peter Lyman Squash and Racquet Center
43. Fauser Stadium
44–48. Susan B. Anthony Halls
44. Gates Hall
45. Gannett Hall
46. Morgan Hall
47. Hollister Hall
48. Danforth Dining Center
49. University Health Service Building
50. Spurrier Hall
51. Riverview Apartments
52–53. Jackson Court
54. Sage Art Center
55. University Security Center
56–61. Hill Court
57. Fairchild House
58. Gale House
59. Mauro House
60. Kendrick House
61. Chambers House
62–67. Mt. Hope Campus
62. 575 Mt. Hope Ave.
63. 590 Mt. Hope Ave.
64. 660 Mt. Hope Ave.
   (Wilmot House)
65. 668 Mt. Hope Ave.
   (Elwanger & Barry Bldg.)
66. 692 Mt. Hope Ave.
   (Patrick Barry House)
67. 695 Mt. Hope Ave.
68. Towne House
69. Data Center Services (DCS)
70. Mt. Hope Professional Bldg.
71. Mail Services Bldg.
72. Goler House
73. Eastman Dental
74. Parking Garage
75. James P. Wilmot Cancer Center
76. Ambulatory Care Facility
77. Hospital Lobby
78. Strong Memorial Hospital
79. Frank and Caroline Gannett Emergency Center
80. Supplies & Accounts Bldg.
81. School of Medicine and Dentistry
82. Medical Center Annex
83. Central Utilities Plant
84. Arthur Kornberg Medical Research Bldg.
   Sarah Flaim Atrium
85. Ernest J. Del Monte Neurology Institute
86. Helen Wood Hall
87. Children’s School at URMC
88. University Park
89–91. Southside Living Center
90. Maisonneues
91. de Kiewiet Tower
92. Valentine Tower
93. University Facilities and Services Building
94. Laboratory for Laser Energetics
95. Robert L. Sproull Center for Ultra High Intensity Laser Research
95–96. Alumni and Advance ment Center
97. Whipple Park Apartments
98. Memorial Art Gallery, Currier Union
99. Memorial Art Gallery
100. Eastman Student Living Center
101. Eastman Annex
102. Eastman School of Music, Kilbourn Hall
103. Miller Center, Sibley Music Library
104. Eastman Theatre
   Kodak Hall
105. Messinger Hall
   Eastman Community Music School
106. Saunders Research Building
107. LeChase Hall
   under construction
108. O’Brien Hall
109. Rettner Hall
   proposed
University of Rochester

Graduate Education

The University of Rochester is an independent university which offers over 50 doctoral programs and some 65 master's programs in the following schools and colleges:

- Arts, Sciences & Engineering
  - School of Arts and Sciences
  - Edmund A. Hajim School of Engineering and Applied Sciences
- Eastman School of Music
- School of Medicine and Dentistry
- School of Nursing
- William E. Simon Graduate School of Business Administration
- Margaret Warner Graduate School of Education and Human Development

The first PhD degree was awarded in 1925, and one of the first three to earn the degree at the University later became a Nobel laureate.

The continuing goal of the University is to prepare promising students for outstanding scholarly and professional achievement—by educating them in the technical skills of a discipline and in the moral values of intellectual life. To this end, the University has been heavily endowed by many benefactors, including George Eastman, founder of Eastman Kodak; Joseph Wilson, founder of Xerox; and Charles F. Hutchison. Today, the University is one of the most highly endowed universities in the nation.

In 2011–12, the University had 1,347 tenure-tracked faculty members and roughly 8,155 full-time students and 1,056 matriculated part-time students. Of the full-time students, 5,348 are undergraduates and 2,807 are graduate students.

These 2,807 graduate students are part of six colleges and dozens of programs. Admission is selective so that graduate students are both academically and intellectually outstanding. As a result, intellectual life within each program can be both intimate and challenging. At the same time, it is possible—and in fact quite common—for students to reach out to other disciplines for scholarly growth.

The great advantage of the University of Rochester is that it offers academic excellence on a personal scale. It is a university that spans the universe of knowledge—yet provides a wealth of opportunities for individual achievement and recognition.

Associated Educational Institutions

Colgate Rochester Crozer Divinity School-Bexley Hall-St. Bernard’s School of Theology and Ministry is an interdenominational seminary offering graduate programs leading to professional degrees for the ministry. While it is geographically separated from the University by about one mile and is governed by its own independent boards, it is affiliated with the University in the sense that students in each institution can take courses in the other and use the libraries of both.

Graduate Student Exchange Scholar Program: Cornell, Syracuse, and Rochester offer graduate students the opportunity, when the appropriate course or facility is unavailable in the home university, to take special courses and seminars and to use the libraries at the other two universities. Inasmuch as each university has unique courses and programs, this exchange considerably expands opportunities for some students. More information about this program is available in the Office of the University Dean of Graduate Studies.
Graduate Student Life

Graduate and Family Housing

Members of the University of Rochester graduate student community can choose from a wide range of living accommodations close to campus in our graduate and family housing areas.

The University maintains apartment complexes that serve graduate students, medical students, and postgraduate trainees (including postdoctoral trainees and fellows, hospital house staff, and fellows of the School of Medicine and Dentistry).

For more information on graduate and family housing, contact the University Apartments Office at (585) 275-5824 or by email at uapts@reslife.rochester.edu or check the website at www.rochester.edu/reslife, select Graduate from the menu.

Eligibility for University housing is contingent on the individual being currently registered as a full-time graduate student or professional trainee of the University of Rochester. Because applications for University housing usually exceed available University facilities, a lottery system is used to establish priority among qualified applicants.

The Office of Residential Life and Housing Services also operates the Community Living Program, which has listings of privately owned apartments, houses, and rooms. For more information on this program, phone (585) 275-1081 or email ochousing@reslife.rochester.edu or check the website at www.rochester.edu/reslife. Select Off Campus from the menu.

Family-Friendly Policies for Graduate Students

All of the schools at the University of Rochester provide accommodation for graduate students for the birth or adoption of children, as outlined in this policy. Students are encouraged to consult the specific administrative offices within their respective schools regarding tuition fees, financial aid, and course credit details.

Parental Leave

Graduate students are eligible for up to eight weeks of leave for the primary caregiver following the birth or the adoption of a child.* During this period, students may postpone course assignments, examinations, and other academic requirements but remain active full-time students, with access to University facilities (including student health insurance, library privileges, and housing) and to University faculty and staff.

While students will continue to be funded at their current pay rate off any existing funding sources (e.g., fellowship, assistantship) during the leave period, students will be excused from regular teaching or research duties.† However, it is the students’ professional responsibility to work with their advisor or faculty member to prepare for the absence in advance of the leave. This includes reviewing the status and continuation of research projects, adequately preparing those who will assume teaching responsibilities during the students’ absence, and arranging for a smooth transition in any other responsibilities. Note that the students’ teaching, research, or other responsibilities may be altered for the semester in which the parental leave is taken.

Eligible graduate students are required to notify their advisor and school dean of graduate studies of the date of their intended time away at least 60 days prior (when possible) to the expected date of childbirth or adoption, using the Parental Leave Request Form. While applications for parental leave are required, the benefit is automatic.

If extended time is needed beyond the eight weeks leave, written approval for an unpaid leave of absence must be requested, and approval obtained from the students’ advisor, program director, and the school’s dean of graduate studies. Note that individual fellowships, such as the NSF Graduate Fellowships, may require sponsor approval for extended leaves of absence. Specific guidelines should be consulted. Students on the University of Rochester student medical health insurance plan should note that coverage is not provided for students while on a leave of absence.

Childcare Options

The Children’s School @ URMC is a KinderCare center located on the University of Rochester campus. As a national leader in managing employer-sponsored childcare centers, quality and curriculum are the cornerstones of KinderCare’s success in preschool education and childcare service. Their curriculum is based on a philosophy of Whole Child Development, centered on the belief that children learn through play and that every child is unique and develops in four distinct areas: social, physical, intellectual, and emotional. You may visit KinderCare’s website at www.kindercare.com; to find The Children’s School @ URMC KinderCare, enter the zip code location of 14642.

Additionally, the University of Rochester Office of Human Resources can provide a list of recommended day care centers in the area: www.rochester.edu/working/hr/familycare/.

Lactation Rooms

A lactation room is available at the University of Rochester Medical Center for graduate students to use to express their milk or breastfeed their child. All University employees and students can use the room by calling 275-4058 to obtain swipe access to the room. The room, which is available 24/7, can accommodate four women at the same time. There are lounge chairs, breast pumps, lockers, and a refrigerator for women to store their milk.

* These guidelines are consistent with the NIH Grants Policy Statement—parental leave (10/10). For those on NIH training grants, the use of parental leave must be approved by the Training Grant PD/PI.
† NIH provides support for administrative supplements to hire temporary technical help for the grant to cover the absence of someone working on the grant due to family leave. See the following websites for more details: http://grants.nih.gov/training/faq_childcare.html#1346 http://funding.niaid.nih.gov/researchfunding/traincareer/pages/petas.aspx.
Family Counseling
The University Counseling Center (UCC) provides individual and couples therapy and yearlong group therapy to members of the University of Rochester community who pay the mandatory student health fee. Support is available for those looking to manage the changes in their lives that occur with the birth or adoption of a child: www.rochester.edu/ucc/index.html.

Graduate Student Organizations
Graduate student organizations are as follows: Arts, Sciences & Engineering, Graduate Organizing Group; Eastman School of Music, Graduate Student Association; School of Medicine and Dentistry, Graduate Student Society; School of Nursing, Doctoral Student Forum; William E. Simon Graduate School of Business Administration, Graduate Business Council; Margaret Warner Graduate School of Education and Human Development, Warner Graduate School Student Association and the Higher Education Student Association.

Health Care Services
Student Health Program
The University Health Service (UHS) provides a full range of confidential, high-quality primary care services for all full-time University students on a prepaid basis through the Student Health Program. Medical care and health promotion services are provided by the University Health Service, and mental health services are provided by the University Counseling Center (UCC). The University Health Service and the University Counseling Center are accredited by the Accreditation Association for Ambulatory Health Care (AAAHC).

Access to medical and mental health care is provided 24 hours a day, seven days a week, throughout the calendar year. Whenever UHS and UCC offices are closed, a physician and a mental health professional are on call and available by phone for urgent concerns. To reach the physician on call, students should call UHS at (585) 275-2662. To reach the mental health professional, students are asked to call UCC at (585) 275-3113.

Health Plan: All full-time students participate in the student health plan. The health plan has two parts. (1) Mandatory health fee: covers unlimited primary care visits with the physicians, nurse practitioners, and registered nurses at the University Health Service; time-limited therapy with mental health professionals at the University Counseling Center; health promotion programs and services; and public health surveillance. All full-time students must pay the mandatory health fee, which entitles them to use the University Health Service and the University Counseling Center throughout the academic year and the following summer (August 1 to July 31), as long as they are enrolled on a full-time basis. (2) Health insurance: covers the cost of services such as surgical procedures, hospitalization, and diagnostic laboratory tests and X-rays. These services are not covered by the mandatory health fee. All full-time students must have health insurance in addition to the mandatory health fee.

Students can enroll in the University-sponsored health insurance or they can waive the insurance if they are covered by health insurance that meets University standards. To be eligible for waiver of the University-sponsored insurance, the students’ insurance plan must be from a U.S.-based company. All waiver requests are audited. International-based companies are not eligible for waiver. Students with international-based insurance will be enrolled in the University-sponsored insurance with an option to submit an appeal of their enrollment by August 15. Students who waive the health insurance are responsible for paying any charges that the University-sponsored plan would have covered. For questions about insurance offered through the University Health Service, check “Health Insurance for Full-Time Students” on the UHS website (www.rochester.edu). Students can also contact the UHS Insurance Advisor at insurance@uhs.rochester.edu for assistance.

Immunization Requirement: Entering full-time and part-time students must provide immunization information to meet New York State and University immunization requirements. These requirements, which are documented on the Health History Form (HHF), should be completed before arrival on campus. Students who are unable to complete the immunization requirements before arriving on campus can do so at the University Health Service (UHS). Since this is a pre-matriculation requirement, students will be charged for the visit and the immunizations. According to New York State law, failure to show proof of immunity to measles, mumps, and rubella will result in students not being allowed to attend classes at the University. A late fee will be charged to students who do not complete the requirements by the first day of classes. For questions about completing the immunization requirement, write to hhf@uhs.rochester.edu.

Information about services for students is available on the UHS website at www.rochester.edu/uhs and the UCC website at www.rochester.edu/ucc.

University Health Service (UHS)
UHS provides a full range of primary care services, including the treatment of illnesses and injuries, women's health care, the management of ongoing medical problems, and advice and treatment for any health concern. In addition, UHS provides allergy injections, immunizations, physical therapy, laboratory testing, referrals to specialists, and health education.

The UHS primary care staff includes registered nurses, nurse practitioners, and physicians who are specialists in internal medicine. To provide students with a more personal and effective interaction, all students are assigned a primary care provider (PCP) at UHS when they begin studies at the University. Students are encouraged to schedule appointments with their PCP when they need health care.

Confidentiality
The relationship between health care providers and their patients is confidential. Notification of others, including parents, friends,
and University faculty and administration, is generally consid-
ered the student’s responsibility unless the condition is serious
and the student is unable to assume responsibility for informing
others. We will not share information about the fact or the nature
of a student’s visit to UHS without the student’s permission.

Locations
The University Health Service has three offices. The office on the
River Campus is in the UHS Building, which is next to Susan
B. Anthony Residence Halls. The office in the Medical Center
is located in 1-5077 in the Medical Center. The office at the
Eastman School of Music is located in Room 106 in the Student
Living Center. Office locations and hours are listed on the UHS
website (www.rochester.edu/uhs). Appointments at any UHS
office are made by calling (585) 275-2662.

After-Hours Medical Care
Access to medical care is provided for students through the
University Health Service 24 hours a day. Throughout the year,
whenever the UHS offices are closed, a UHS physician is on call
and available by phone, (585) 275-2662, from home for urgent
concerns that cannot wait until the offices reopen. Unless it is
an extreme emergency or a life-threatening situation, students
should always call the University Health Service before seeking
medical care elsewhere.

Health Promotion
The UHS Health Promotion Office promotes the health and
wellness of students by providing educational programs and
activities that encourage the development of a healthy lifestyle
and the effective use of health care services. The UHS Health
Promotion Office provides opportunities for students to become
involved in learning and educating their peers. For more infor-
ination, check “Health Promotion” on the UHS website (www.
rochester.edu/uhs) or call (585) 273-5775.

UHS Website (www.rochester.edu/uhs)
The UHS website provides detailed information about the
services provided by UHS, the locations and hours, the cli-
cial staff, the mandatory health fee, health insurance, and health
promotion services. In addition, the site provides fact sheets
on a number of health topics and links to online health care
resources.

University Counseling Center (UCC)
The University Counseling Center (UCC) offers time-limited
individual and couples therapy and yearlong group therapy
to full-time students. Students use UCC services for a variety
of problems including anxiety, apprehension about major life
decisions, depression, relationship difficulties, family problems,
eating problems, grief, sexual functioning, sexual identity, and
general discomfort about what is happening in their lives. In ad-
tion to working with individuals and couples, the University
Counseling Center offers a variety of therapy/support groups
on such topics as women’s issues, men’s issues, adult children of
alcoholics, survivors of sexual abuse, bereavement, and students
with eating disorders. Staff members are also available to discuss
topics or concerns of special interest to groups of students.

The therapists at the University Counseling Center are li-
censed professionals and professionals-in-training from a variety
of mental health disciplines. They employ many treatment ap-
proaches and draw upon a wide range of training and experience
in the field of psychotherapy. Therapists are available to provide
prescription medication in conjunction with therapy.

Confidentiality
All contacts with a University Counseling Center therapist are
confidential. The fact that students are using UCC will not be
disclosed to any University official or faculty member, or to
family, friends, or roommates without the permission of the
students. UCC will not release any clinical information about
students’ visits, even with the students’ written request, except to
another therapist for purposes of further treatment. In addition,
because of the sensitive nature of visits, extreme care is taken to
protect the confidentiality of our records. UCC records are sepa-
rate from Strong Memorial Hospital medical records.

Locations
The University Counseling Center (UCC) is located on the
third floor of the UHS Building on the River Campus. UCC
also has offices at the Eastman School of Music and in the
Medical Center. For office locations and hours, check the UCC
website at www.rochester.edu/ucc. Appointments are made by
calling (585) 275-3113.

Urgent Situations and After-Hours Care
The University Counseling Center offers on-call emergency ser-
vice 24 hours a day throughout the year for students who are dis-
tressed themselves or who are concerned about someone else. The
professional-on-call can be reached by calling (585) 275-3113.

UCC Website (www.rochester.edu/ucc)
The UCC website provides information about the locations, hours,
services offered for students, staffing, online resources, self help, and
more. Mental health questions can be addressed to the UCC online
resource, “Dear Dr. Ana-Lyze.” Designed as a forum for discourse
on mental health concerns, this site is to be used strictly as an educa-
tional tool and in no way attempts to replace formal therapy.

Student Support
The Center for Excellence in Teaching and Learning (107 Lat-
timore) provides individual and group programs for students who
want to improve their academic performance. CETL also offers
individual consultations and roundtable discussions to help TAs
improve their teaching skills. For more information, please call 275-
9049 or check our website at www.rochester.edu/College/cetl.

The booklet Classroom Accommodations, A Guide for
Students with Disabilities is available through the Center for Ex-
cellence in Teaching and Learning at 275-9049 or through the
Office of the University Coordinator of Disability Resources at
275-5550. Staff in these offices work closely with students with
disabilities to verify documentation of the existence of a disability,
implement reasonable classroom accommodations, coordinate support services, and identify campus resources. Students who have questions or concerns about making a decision to self-identify the existence of a disability should contact the University Coordinator at 275-5550 for a confidential discussion. Additional information is available online at www.rochester.edu/ada.

University Intercessors are available to serve as a resource for solving problems that are not easily resolved after a first attempt. Students, staff, and faculty members who have concerns that cannot be worked out through obvious channels are encouraged to contact an intercessor for assistance. Intercessors are particularly interested in identifying patterns that indicate a need to change organizational structures or procedures. Helping individuals is an important way to learn what needs to be done to improve the University environment. The intercessors serve as a resource to members of the University community who wish to discuss concerns regarding discrimination and harassment; disability issues; and disagreements among faculty, staff, and students that cannot be resolved by other means. The intercessors can be reached by phone at 275-5931 or at www.rochester.edu/intercessor.

International Services Office

The International Services Office (ISO) provides a full range of programs and services throughout the University for approximately 1,750 international students and 600 scholars and employees plus their dependents from 110 countries. The staff administers the F-1, J-1, H-1B, O-1, and TN visa programs. The ISO supports admitting and hiring departments and issues visa documents, provides advice on immigration regulations affecting internationals, and processes immigration benefits such as employment authorizations and extensions of stay. The ISO is the University’s official liaison with the U.S. Department of Homeland Security, the Student Exchange Visitor Program (SEVIS), the Department of State, and foreign and American consulates and embassies, as well as offices of local government agencies such as the Social Security Administration and the Department of Motor Vehicles. The ISO works closely with members of the University community to advocate for and address the various needs of international students and scholars.

The ISO also serves as a resource to help internationals and their dependents adjust to the United States, the University, and the community of Rochester. Services and programs include individual immigration check-ins; new student orientation programs; individual advising and counseling appointments; a biweekly email newsletter; travel, employment, and tax workshops; pre-arrival and living in Rochester information; and a comprehensive website (www.iso.rochester.edu). The ISO is located in 213 Morey Hall and can be contacted by phone at (585) 275-2866 and by email at questions@iso.rochester.edu.

Health and Safety

Policy: It is the policy of the University of Rochester to provide an environment free from recognized hazards that could cause injury or illness to faculty, staff, students, patients, and visitors, and to protect its facilities from risk of damage from unsafe acts or conditions.

In order to provide direction in achieving the stated aims of the policy, an Environmental Health and Safety Department was formed. The department director is the chief safety officer for the University as well as the safety officer for Strong Memorial Hospital.

The department is responsible for fire safety through the Fire Marshal’s Office; food safety through the Sanitarian’s Office; pest control through the Pest Control Unit; occupational safety and health through the Occupational Safety Unit; and radiation safety issues through the Radiation Safety Unit. Within the several areas of expertise, these units provide guidance, consultation and training, and perform inspections and tests of facilities and procedures.

Heavy reliance for ongoing safety programs is placed on departments and similar major subdivisions of the University, in recognition of the very wide diversity of interests of these subdivisions, and equally, to minimize the surveillance and policing stigma commonly attached to safety departments.

Interfaith Chapel

The Interfaith Chapel is the center for religious and spiritual life on the River Campus. The chapel staff offers graduate students opportunities for worship and meditation, social service, personal counseling, and cultural and social events. For further information, call 275-4321.

University Security Services

The University of Rochester’s annual security report includes statistics for the previous three years concerning reported crimes that occurred on campus; in certain off-campus buildings owned or controlled by the University; and on public property within, or immediately adjacent to and accessible from, the University’s campuses. The report also includes institutional policies regarding campus security, alcohol and drug use, crime prevention, the reporting of crimes, sexual assault, and other matters. You can obtain a copy of this report, titled Think Safe, by contacting University Security Services at (585) 275-3340, or view the contents by accessing the following website: www.security.rochester.edu.

Information on sexual harassment policies and procedures is published in the University’s Policy Against Discrimination and Harassment and can be viewed at www.rochester.edu/working/hr/policies/pdfpolicies/106.pdf. Additional information is available by calling the Intercessor’s Office at (585) 275-9125.

How to Contact Security

The University maintains an extensive network of over 500 interior and exterior public access telephones. You can call the Security Communications Center for assistance any time of the day or night from any of these phones. Included are over 185 direct-dial Blue Light Emergency Phones.

In an EMERGENCY, dial x13 from any University phone, including service phones located at building entrances. Pick up a Blue Light Emergency Phone located on or near walkways and parking lots. By cell phone, dial (585) 275-1333. AT&T or Verizon callers may dial #413, a free call to University Security in the Rochester area. An officer will be sent to your location right away. Local police,
fire, or ambulance agencies will be notified as needed. (Currently, if you call 911 from within the University phone system, your exact location will not be displayed to the 911 system operator.)

For nonemergencies, dial (585) 275-3333. You may also use a Blue Light Emergency Phone.

The dispatcher will determine first that you are safe. Once that is known, you will be asked for your name and location as well as descriptive information about the incident or event with which you are involved. This information will assist the responding security officer(s) and the police or other emergency responders.

You may contact an on-duty supervisor, 24 hours a day, by calling (585) 275-3333.

For crime prevention services, call (585) 275-2220. For investigative services, call (585) 275-3436. For victim’s assistance, call (585) 275-2090.

Where to Find Security
Our administrative offices are located at the University Security Center, 612 Wilson Boulevard. Office hours are 8:30 a.m. to 5 p.m. weekdays. Call (585) 275-3340 or (585) 275-3437, fax (585) 275-0344, or send email to 4_info@security.rochester.edu for more information. Our website is at www.security.rochester.edu.

Also on the River Campus, we’re in the garden level of the Community Learning Center. Office hours are from 8:30 a.m. to 5 p.m. weekdays. Call (585) 273-5200 or fax (585) 273-1128.

We are located in the Medical Center in Room G-6009 (near the bookstore and bank). Office hours are from 8:30 a.m. to 5 p.m. weekdays. Call (585) 275-2221 or fax (585) 271-4513.

We are available to meet with students at the Eastman School of Music. We have space in the ESM main hall and in the main lobby of the Student Living Center. Call (585) 273-5200.

Security Telephone Numbers to Remember
- Security/Fire/Ambulance EMERGENCY: Dial 13 from any University telephone
- From AT&T and Verizon cell phones: #413
- From any cell phone: (585) 275-3333
- Nonemergencies: (585) 275-3333
- River Campus and Eastman Office: (585) 273-5200
- Medical Center Office: (585) 275-2221
- Administrative and Patrol Operations Staff: (585) 275-3340
- General Information (e-mail): 4_info@security.rochester.edu
- Special Events: (585) 275-1087
- Lost/Found Property: (585) 275-2552
- Victim Assistance Coordinator: (585) 275-2090

For more information, please visit our website at www.security.rochester.edu.
Financial Information

Tuition and Fees

Graduate tuition at Rochester pays only a portion of actual educational costs. The balance is met by income from endowment and by support from individuals, foundations, corporations, and governments.

Rates for the 2012–2013 academic year are shown below and are subject to revision.

Rates for 2013–2014 may be different from the rates shown below; if so, new information about tuition and fees will be issued.

Tuition

<table>
<thead>
<tr>
<th>Course Description</th>
<th>Tuition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arts, Sciences &amp; Engineering and the School of Medicine and Dentistry MS and PhD programs</td>
<td>$1,340/credit hour</td>
</tr>
<tr>
<td>Technical Entrepreneurship &amp; Management</td>
<td>$1,574/credit hour</td>
</tr>
<tr>
<td>Margaret Warner Graduate School of Education and Human Development</td>
<td>$1,202/credit hour</td>
</tr>
<tr>
<td>School of Nursing</td>
<td>$1,206/credit hour</td>
</tr>
<tr>
<td>William E. Simon Graduate School of Business Administration</td>
<td>$1,574/credit hour</td>
</tr>
<tr>
<td>School of Medicine and Dentistry (MD program)</td>
<td>$44,700 (annual)</td>
</tr>
<tr>
<td>Eastman School of Music</td>
<td>$1,275/credit hour*</td>
</tr>
<tr>
<td>899: master's dissertation, per semester</td>
<td>$1,035</td>
</tr>
<tr>
<td>999: doctoral dissertation, per semester</td>
<td>$1,035</td>
</tr>
<tr>
<td>Each of the above, Eastman School of Music, per semester</td>
<td>$1,035</td>
</tr>
<tr>
<td>Each of the above, Simon School, per quarter</td>
<td>$500</td>
</tr>
</tbody>
</table>

Part-Time Graduate Tuition

<table>
<thead>
<tr>
<th>Course Description</th>
<th>Tuition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nonmatriculated students in the School of Arts and Sciences†</td>
<td>$752/credit hour</td>
</tr>
<tr>
<td>Edmund A. Hajim School of Engineering and Applied Sciences</td>
<td>$1,340/credit hour</td>
</tr>
<tr>
<td>Eastman School of Music excluding applied music courses</td>
<td>$1,275/credit hour</td>
</tr>
<tr>
<td>Applied music courses</td>
<td>varies</td>
</tr>
<tr>
<td>School of Medicine and Dentistry</td>
<td>$1,340/credit hour</td>
</tr>
<tr>
<td>School of Nursing</td>
<td>$1,206/credit hour</td>
</tr>
<tr>
<td>William E. Simon Graduate School of Business Administration</td>
<td>$1,574/credit hour</td>
</tr>
<tr>
<td>Margaret Warner Graduate School of Education and Human Development</td>
<td>$1,202/credit hour</td>
</tr>
</tbody>
</table>

* Per credit hour rate does not apply to music lessons. Cost for music lessons varies. Please verify charges with the associate director for administration (274-1030).
† Maximum of one course taken as nonmatriculated student may be approved for use in graduate program for matriculated arts and sciences graduate student.

Fees

The fee for auditing courses is $170 per credit hour, except for courses in the Simon School and the Eastman School of Music. The auditing fee for the Eastman School of Music is $160 per course. The Simon School’s auditing fee is $2,164 per course.

Senior citizens (age 60 and over) and alumni will receive a discount of $250 for each credit-bearing course and $100 per audited course. Alumni who are senior citizens will receive a $500 discount for each credit-bearing course and $200 per audited course (this discount does not apply at Simon School). These discounts apply only to nonmatriculated students.
Other Fees

<table>
<thead>
<tr>
<th>Fee</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mandatory Health Service Fee charged to all full-time students</td>
<td>$480</td>
</tr>
<tr>
<td>Late registration fee*</td>
<td>$160</td>
</tr>
<tr>
<td>Thesis Archive fee for the EdD degree before registering the dissertation</td>
<td>$70</td>
</tr>
<tr>
<td>Health History Form late fee</td>
<td>$30</td>
</tr>
<tr>
<td>895: continuation of master’s enrollment, per semester</td>
<td>$1,035</td>
</tr>
<tr>
<td>995: continuation of doctoral enrollment, per semester</td>
<td>$1,035</td>
</tr>
<tr>
<td>For William E. Simon Graduate School of Business Administration, 995, per quarter</td>
<td>$500</td>
</tr>
<tr>
<td>For Eastman School of Music, 895 and 995, per semester†</td>
<td>$1,035</td>
</tr>
<tr>
<td>985: leave of absence, per semester</td>
<td>$60</td>
</tr>
<tr>
<td>For the Eastman School of Music and School of Nursing, 985, per semester</td>
<td>$60</td>
</tr>
</tbody>
</table>

Noncredit course fees. All persons attending noncredit courses must pay fees as announced for these courses.

* Registration must be completed for all credit-carrying courses and research by the end of the second week of classes after the semester begins, or a penalty charge is assessed. Registration deadlines for matriculated students in the School of Nursing may vary. For specific deadline dates, call the School of Nursing registrar at 275-8832.

† Please verify all Eastman School of Music tuition charges with the associate director for administration at 274-1030.

Payment Policy
For nonmatriculated students, one-half the amount due the University for a semester is due at the time of registration, and the remaining balance is due by the 10th of the following month. For matriculated students, and students enrolled in the William E. Simon Graduate School of Business Administration, the University offers a two-payment plan each semester/quarter. A fee of 1 percent of any unpaid amount is charged for each month or part of a month that payment remains past due. For additional information, students should contact the Bursar, University of Rochester, Rochester, New York 14627-0037; (585) 275-3931. Students in the School of Medicine and Dentistry should contact the Bursar, School of Medicine and Dentistry, 601 Elmwood Avenue, Rochester, New York 14642-8601; (585) 275-4672.

Refund Policy
Students official withdrawal or inactive date is determined when they formally change their status with their college’s Dean’s Office. It is this official “Change of Status” form that alerts the Registrar, Bursar, Financial Aid, and other appropriate offices to adjust the student’s accounts.

Refund schedules are available on the Bursar Web site: www.rochester.edu/adminfinance/bursar.

Students declaring withdrawal or inactive status for medical reasons or other extraordinary circumstances may be granted prorated charges throughout the term with the approval of their college’s dean.

Adjustments to Financial Aid
Federal regulations determine how the Financial Aid Office calculates the adjustments to financial aid to reflect reduced tuition and fees. These regulations do not permit a proration of aid in the same manner that is charged for tuition and fees. Any credit balance created by reduced charges must first be used to repay federal aid, next to state aid, third to the institution’s aid programs, and finally to the student.

If an adjustment to financial aid is received, financial aid award will be reduced in the following order: Unsubsidized Federal Direct Loan, Subsidized Federal Direct Loan, Federal Perkins Loan, Federal PLUS Loan, Federal Pell Grant, Federal SEOG. Additional adjustments may be made to state aid, private aid, and institutional aid based on the student’s withdrawal date.

Examples of refund calculations for students receiving financial aid are available to review at the Financial Aid Office. If a student is considering withdrawing or taking inactive status, he or she should consult with a counselor in the Financial Aid Office to review the examples.

The Bursar’s Office and the Financial Aid Office will work together after receiving an official Change of Status notice from the Dean’s Office to determine these adjustments. Every attempt will be made to complete the refund calculation within 30 days of the change of status.
Financial Awards

Many students are able to pursue graduate studies by receiving financial aid from the University. Students should also apply for fellowships granted by private foundations, the federal government (e.g., the National Science Foundation), and by various state organizations.

It is the responsibility of all graduate students to inform their college of financial aid they receive from non-University sources.

Graduate Fellowships and Assistantships

The University awards a large number of fellowships, assistantships, and scholarships to help graduate students meet the cost of education. Whether the funds for these awards come ultimately from individuals, corporations, foundations, government agencies, or the University itself, the amount and nature of the awards are decided by officers of the University.

Awards are made for various periods of time, and all awards are contingent upon satisfactory academic progress. Awards may be terminated at any time if academic performance is unsatisfactory. For those fellowships awarded directly to students from non-University sources, such as foundations or government agencies, the term of the grant is up to the donor. Nevertheless, holders of non-University fellowships may be terminated from a degree program during the term of the award if they do not maintain satisfactory academic standing.

Graduate fellowships are intended to further the recipients' education and recipients are expected to devote full time to their studies and to any required teaching, research, or training.

Acceptance of Departmental Financial Assistance

The University of Rochester, as a member of the Council of Graduate Schools in the United States, subscribes to the following statement, which has been adopted by most of the leading graduate schools in North America:

“Acceptance of an offer of financial support (such as a graduate scholarship, fellowship, traineeship, or assistantship) for the next academic year by a prospective or enrolled graduate student completes an agreement that both student and graduate school expect to honor. In that context, the conditions affecting such offers and their acceptance must be defined carefully and understood by all parties.

“Students are under no obligation to respond to offers of financial support prior to April 15; earlier deadlines for acceptance of such offers violate the intent of this Resolution. In those instances in which a student accepts an offer before April 15, and subsequently desires to withdraw acceptance, the student may submit in writing a resignation of the appointment at any time through April 15. However, an acceptance given or left in force after April 15 commits the student not to accept another offer without first obtaining a written release from the institution to which a commitment has been made. Similarly, an offer by an institution after April 15 is conditional on presentation by the student of the written release from any previously accepted offer. It is further agreed by the institutions and organizations subscribing to the above Resolution that a copy of this Resolution should accompany every scholarship, fellowship, traineeship, and assistantship offer.”

Financial Assistance

Federal Aid Program: Graduate students may borrow an unsubsidized loan up to a maximum of $20,500 per academic year through the Federal Direct Loan program. Students must be a citizen or eligible non-citizen, registered for at least part time (minimum 6 credit hours) status, and be matriculated in a degree-seeking program to receive these loans. The actual amount a student is eligible to borrow cannot exceed the University of Rochester’s cost of attendance minus any other assistance received (including departmental awards). To apply for a federal loan, students must complete the Free Application for Federal Student Aid (FAFSA) online at www.fafsa.ed.gov.

Additional Aid Options: The federal Graduate PLUS loan is based on credit-worthiness, which is determined by the federal government. There is a fixed interest rate of 7.9 percent. There is no grace period associated with the loan, but students may defer payments while they are enrolled at least part time. Applications are available online at www.studentloans.gov. Students must have already applied for the federal Direct Unsubsidized loan before applying for the federal Graduate PLUS loan program.

Students may opt for a private or alternative loan instead of the suggested federal loans. Please be aware that these loans are based upon credit-worthiness and have variable interest rates, as determined by the individual lenders. Students must complete an application and be approved by the lender before funds will disburse to their student account. Please be aware that a co-borrower may be required for some students.

For additional information on loan options, please visit the Financial Aid Office’s website at www.rochester.enrollment.edu/financialaid.

Please contact the appropriate school for financial aid application instructions:

If you are applying to the Eastman School of Music, please contact: Office of the Director of Financial Aid, Room 103, Eastman School of Music, 26 Gibbs Street, Rochester, New York 14604-2599.

If you are applying to the School of Medicine and Dentistry, please contact: Office of Financial Aid, School of Medicine and Dentistry, 601 Elmwood Avenue, Box 601, Rochester, New York 14642-0001.

All other schools and colleges of the University (the School of Arts and Sciences, the Hajim School of Engineering and Applied Sciences, the Warner School of Education, the Simon School of Business, and the School of Nursing): Financial Aid Office, University of Rochester, P.O. Box 270261, Rochester, NY 14627-0261. Phone number: (585)275-3226.
Graduate Degrees

The University offers the following graduate degrees: Master of Arts, Master of Arts in Teaching, Master of Business Administration, Master of Music, Master of Public Health, Master of Science, Doctor of Education, Doctor of Medicine, Doctor of Musical Arts, Doctor of Nursing Practice, and Doctor of Philosophy. Information about specific graduate programs is available elsewhere in this bulletin and at www.rochester.edu/gradstudies.

The Degree Doctor of Philosophy

The requirements for the degree of Doctor of Philosophy are described in the section of this Bulletin titled "Regulations and University Policies Concerning Graduate Study."

The degree Doctor of Philosophy is awarded by the University of Rochester in the following subjects:

**School of Arts and Sciences**
- Biology
- Brain and Cognitive Sciences
- Chemistry
- Economics
- English
- Geosciences
- History
- Linguistics*
- Mathematics
- Philosophy
- Physics
- Physics and Astronomy
- Political Science
- Psychology (Clinical, Developmental, and Social-Personality)
- Visual and Cultural Studies

**Edmund A. Hajim School of Engineering and Applied Sciences**
- Biomedical Engineering
- Chemical Engineering
- Computer Science
- Electrical Engineering
- Materials Science
- Mechanical Engineering
- Optics

**Eastman School of Music**
- Music Composition
- Music Education
- Music Theory
- Musicology

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* New enrollments suspended.

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**School of Medicine and Dentistry**
- Biochemistry
- Biophysics
- Epidemiology
- Genetics
- Health Services Research and Policy
- Microbiology and Immunology
- Neurobiology and Anatomy
- Neuroscience
- Pathology
- Pharmacology
- Physiology
- Statistics
- Toxicology
- Translational Biomedical Science

**School of Nursing**
- Health Practice Research

**William E. Simon Graduate School of Business Administration**
- Business Administration

**Margaret Warner Graduate School of Education and Human Development**
- Education

**The Degrees Doctor of Musical Arts, Doctor of Medicine, Doctor of Nursing Practice, and Doctor of Education**

Information and requirements for the Doctor of Musical Arts at the Eastman School of Music may be found at www.esm.rochester.edu; for the Doctor of Medicine at the School of Medicine and Dentistry, www.urmc.rochester.edu/smd; for the Doctor of Nursing Practice at the School of Nursing, www.son.rochester.edu; and for the Doctor of Education at the Margaret Warner Graduate School of Education and Human Development, www.warner.rochester.edu.

**The Degrees of Master of Arts and Master of Science**

The master’s degree is awarded in arts, science, engineering, music, medical sciences, nursing, business administration, and education. The administration of work for the master’s degree is vested in the associate dean for graduate studies and the Committee on Graduate Studies in each school or college. Two plans of study are available to students working toward the master’s degree. A candidate for the degree in Plan A must complete a dissertation and pass an oral examination on the dissertation. Under Plan B, a dissertation is not required; but most departments require that a candidate for the degree in Plan B pass a comprehensive examination. It is recommended that the individual check with the relevant department for its requirements. The list below indicates whether the degree can be completed under Plan A, Plan B, or either.
Other requirements for master’s degrees are described in the section of this bulletin titled "Regulations and University Policies Concerning Graduate Study."

**School of Arts and Sciences**
- Biology (MS) A,B
- Brain and Cognitive Sciences (MS) A,B
- Chemistry (MS) A,B
- Comparative Literature (MS) A,B
- Economics (MS) B
- English (MS) B
- French (MS) A,B
- Geological Sciences (MS) A,B
- German (MS) A,B
- History (MS) A,B
- Interdepartmental Studies (MS, MS) A,B
- Linguistics (MS) A,B
- Literary Translation (MS) A
- Mathematical Methods (MS) B
- Mathematics (MS) A,B
- Mathematics-Statistics (MS) B
- Philosophy (MS) A,B
- Physics (MS) B, (MS) A
- Political Science (MS) A,B
- Psychology (MS) A,B
- Spanish (MS) A, B
- Visual and Cultural Studies (MS) B

**Edmund A. Hajim School of Engineering and Applied Sciences**
- Alternative Energy (MS)
- Biomedical Engineering (MS) A,B
- Chemical Engineering (MS) A,B
- Computer Science (MS) B
- Electrical Engineering (MS) A,B
- Materials Science (MS) A,B
- Mechanical Engineering (MS) A,B
- Optics (MS) A,B
- Technical Entrepreneurship and Management (MS)

**Eastman School of Music**
- Ethnomusicology (MS)
- Music Composition (MS) A
- Music Education (MS) A
- Music Education with Initial Certification (MS)
- Music Education with Professional Certification (MS)
- Music Theory (MS) B
- Music Theory Pedagogy (MS) B
- Musicology (MS) B

**School of Medicine and Dentistry**
- Biochemistry (MS) A,B
- Biophysics (MS) A,B
- Clinical Investigation (MS) A
- Clinical Translational Research (MS) A
- Dental Science (MS) A
- Genetics (MS) A,B
- Marriage and Family Therapy (MS) A,B
- Medical Informatics (MS)
- Medical Statistics (MS) B
- Microbiology-Medical (MS) A,B
- Neurobiology and Anatomy (MS) A,B
- Neuroscience (MS) A,B
- Pathology (MS) A
- Pharmacology (MS) A,B
- Physiology (MS) A,B
- Statistics (MS) B
- Toxicology (MS) A,B

**School of Nursing**
- (offered as traditional and accelerated programs)
  - Adult Nurse Practitioner (MS) A,B
  - Adult Nurse Practitioner/Geriatric Nurse Practitioner (MS) A,B
  - Care of Children and Families—Pediatric Nurse Practitioner/Neonatal Nurse Practitioner (MS) A,B
  - Care of Children and Families—Pediatric Nurse Practitioner/Pediatric Behavioral Health (MS) A,B
  - Care of Children and Families—Pediatric Nurse Practitioner (MS) A,B
  - Clinical Nurse Leader (MS)
  - Family Nurse Practitioner (MS) A,B
  - Leadership in Health Care Systems (MS) B
  - Child and Adolescent Psychiatric Mental Health Nurse Practitioner (MS) A,B
  - Pediatric Nurse Practitioner/Psychiatric/Mental Health Nurse Practitioner (MS) A,B
  - Psychiatric/Mental Health Nurse Practitioner (MS) A,B

**William E. Simon Graduate School of Business Administration**
- Accountancy (MS)
- Business Administration (MS) A
- Finance (MS)

**Margaret Warner Graduate School of Education and Human Development**
- School Counseling (MS)
- Community Mental Health Counseling (MS)
- Educational Policy (MS)
- Higher Education Administration (MS)
- Higher Education Student Affairs (MS)
- Health Professions Education (MS)
- Human Development (MS)
- K–12 School Leadership (MS)
- Teaching and Curriculum (MS)
- Early Childhood Education (MS)
- Childhood Education (MS)
- Adolescence Education (MS)
- TESOL/Teaching English to Speakers of Other Languages (MS)
- Teaching Students with Disabilities (MS)
- Reading and Literacies (MS)
- See www.warner.rochester.edu for specific degree offerings.
Other Master’s Degrees

The University of Rochester offers other master’s degrees as follows:

1. Master of Business Administration through the William E. Simon Graduate School of Business Administration. (See page 235.)
2. Master of Music through the Eastman School of Music. (See page 161.)
3. Master of Arts in Teaching through the Margaret Warner Graduate School of Education and Human Development. (See page 242.)
4. Master of Public Health through the School of Medicine and Dentistry. (See page 199.)
The University grants the Doctor of Philosophy degree and administers the award of this degree centrally in the Office of the University Dean of Graduate Studies. The general requirements for the PhD are set at the University level, as described later in this Bulletin. The Council on Graduate Studies recommends to the Provost for transmission to the Board of Trustees all candidates for the Doctor of Philosophy degree.

Schools and interdisciplinary programs offer approved PhD programs under University policies described in this Bulletin. More specific requirements for degree programs may be set by individual schools and departments.

General requirements for the MA and MS degrees are set at the University level and described in this Bulletin. General requirements for other master’s degrees and specific requirements for all master’s degree programs are set by individual schools.

The administration of work for master’s degrees and for doctorates other than the PhD is vested in the associate dean of graduate studies and the Committee on Graduate Studies or equivalent in each school. Each school recommends its candidates for graduate degrees other than the PhD to the Provost for transmission to the Board of Trustees. If a candidate for one of these degrees has taken work in more than one school in the University, the recommendation for award of the degree originates in the school responsible for the student's major department or program.

University Policies for All Graduate Programs

Admission

Admission to graduate studies is granted to graduates of accredited colleges/universities, technical schools, and music schools who present satisfactory evidence of ability to pursue graduate study. Additional admission requirements are set by certain schools of the University. These are stated separately in the general announcements of each school in this bulletin.

An applicant's qualifications are examined by the relevant department/program of major interest and by the associate dean of graduate studies in the appropriate school to determine whether previous training and ability promise success in work.

The master's degree is offered in arts, science, music, engineering, nursing, business administration, accountancy, and education. Information on master's degrees other than MA and MS can be found as follows: for the Master of Business Administration and Master of Science in Accountancy through the William E. Simon Graduate School of Business Administration, see www.simon.rochester.edu. For the Master of Music through the Eastman School of Music, see www.esm.rochester.edu, for the Master of Public Health through the Department of Community and Preventive Medicine in the School of Medicine and Dentistry, see www.urmc.rochester.edu/cpm.

Administration of Graduate Studies

As authorized by the Board of Trustees in a Charter for Administration of Graduate Studies, the Provost assigns responsibility for the administration of all post-baccalaureate work within each school to the dean of that school, who may delegate it to an associate dean of graduate studies or to another appropriate official. Policies for graduate work within each school are determined by the respective faculties and their administrative officers in accordance with the provisions in these Regulations.
Registration

A matriculated graduate student is one who has been admitted to a graduate degree program and has completed initial registration in that program. Once matriculated, a graduate student must maintain continuous enrollment by registering each academic year semester (every quarter in the Simon School) and paying required fees until all requirements for the degree are completed. Auditing a course does not fulfill this requirement. Requirement for summer registration varies by program.

Registration must be completed within two weeks after the beginning of a semester for all courses that carry credit. Late registration is accepted with the payment of a late registration fee.

Dropped Courses

A regular semester course may be dropped at any time through the sixth week of classes, provided the student obtains the approval of his or her faculty advisor and the instructor(s), notifies the graduate registrar on the proper form, and the change does not alter the student's time status. No record of such actions appears on the official transcript.

Following the start of the seventh week of classes, a drop notification (or a change from credit to audit) sent to the graduate registrar must bear the signatures of the faculty advisor, course instructor(s), and associate dean of graduate studies. Such late drops will be recorded on the official transcript and identified by the grade W. At the option of the course instructor, a grade of E may also be attached.

In exceptional circumstances, the associate dean of graduate studies may approve dropping a course without record after the start of the seventh week of classes. Review of the circumstances is initiated by an appropriate written petition.

Dropping credit hours after the seventh week of a semester or retroactive after the conclusion of the semester is not permitted if the change affects the student's time status (full-time status changes to part-time status) for that particular semester.

No academic credit is granted for courses in progress at the time a student withdraws from the University, except by explicit approval of the associate dean acting upon a written petition.

Audited Courses

Audit of a course related to a degree program is permitted for full-time and part-time graduate students, when approved by the student’s faculty advisor, the course instructor(s), and the associate dean of graduate studies. There is a fee for this. With the approval of the associate dean of graduate studies, the school may decide to pay this fee. The audited course will appear on the student's transcript provided the student attends throughout the course. Students who wish later to receive credit for such a course may do so by (1) changing the registration in the office of the graduate registrar prior to the end of the sixth full week of classes in a given semester and (2) paying the required tuition for the course.

Full-time Status

A full-time graduate student is defined as a student who registers for at least 12 hours of credit for the semester (or 9 hours of credit for the quarter at the Simon School), or a graduate assistant or other student doing work equivalent to that of an assistant who registers for at least 9 hours of credit for the semester. Master’s students in the School of Nursing should consult the School of Nursing Student Handbook regarding credit requirements for full-time status.

Change of time status (i.e., full time to part time, or full time to x-time) requires approval from the associate dean, except for the Warner School and the School of Nursing.
Residency
A student is defined as being in residence at the University of Rochester if he or she is registered as a full-time student and is using the facilities of the University (laboratories, libraries, consultations with faculty members, or course attendance) with sufficient frequency and regularity to establish this status clearly. Some period of residence at this University is required for all advanced degrees. (See departmental residency requirements stated in this bulletin.)

Summer Residency Status
Requirements for registration during summer sessions vary across graduate programs. Any student who has been classified as full time during the preceding academic year and is registered for the summer is considered full-time during the summer regardless of summer credit load. Students in residence but not registered for summer credit may register for “990: doctoral summer in residence” or “890: master’s summer in residence” and will not be subject to summer tuition charges.

Study in Absentia or Special Status
In certain circumstances it may be desirable for a matriculated graduate student to engage in full-time or part-time study or research for a limited period of time at another university, research organization, or scholarly institution and to register for appropriate graduate credit or dissertation status at the University of Rochester. All such requests must be made in writing. Advance approval by the associate dean of graduate studies may be required.

Grades
Grades for graduate students are reported on one of two systems. One is A (excellent), A–, B+, B (good), B–, C (poor), and E (failure). The other is S (satisfactory) and E (failure). (See the bulletin of the Eastman School of Music for the grading system in effect for that School.)

The grade S may not be used for any student in a class in which the other students are graded on the A, A–, B+, B, B–, C, E scale (except “591” and “595”).

Minimum grades for courses or research work carrying graduate credit are C or S. C is, however, considered to be a failing grade for any student who is on probation. Moreover, a student who receives the grade of C in each of two courses, or for eight hours of work toward the degree (even if in only one course), will thereby have raised the question of the adequacy of his or her academic performance. In those circumstances the student’s record must be reviewed by the associate dean of graduate studies (in the School of Nursing, the Student Affairs Committee) in consultation with the student and the program director. Individual schools may have established higher minimum standards.

The following grades are also assigned to courses: I, assignments not completed, and W, withdrawal from a course.

Courses or research for which a student has registered and which are graded I (incomplete) must be completed within the time period stated by the professor. Matriculated graduate students in Arts, Sciences and Engineering should refer to the “Policies Governing Use of the Grade of Incomplete in Graduate Courses” in the relevant section of the Bulletin. It is the responsibility of the student to complete the work; the professor may replace the grade of incomplete with IE (failure) or with a passing grade at any time. Retroactive dropping of credit hours after the conclusion of a semester is not permitted if the change affects the student’s time status (full-time status changes to part-time status) for that particular semester.

Leaves of Absence
Leave of Absence (Non-Medical)
The associate dean of graduate studies may grant a leave of absence to a matriculated graduate student who has not yet completed all requirements for the degree. The leave will ordinarily be limited to one year. Students must register for “985: leave of absence” each semester they are in this category and must pay the designated fee. It should be noted that registration of “985: leave of absence” does count toward the degree time limit.

Leave of absence is an x-time category of registration, which has implications for health insurance eligibility, possible loan deferments, and visa status. X-time is defined as neither a full-time nor part-time student, but is used to maintain a student’s place in their graduate program so that they will not be considered withdrawn by the University.

Medical Leave of Absence
On occasion, a serious health problem requires a student to go on inactive status before the end of a semester. In that situation, it may be reasonable to give the student a pro-rated refund on tuition and certain fees. Associated with this special consideration is the right of the University to determine (1) whether the leave is justified on medical grounds and (2) whether the student has recovered sufficiently to return at some point in the future.

Any student who wishes to start a medical leave of absence mid-semester must petition the student’s school. The school will then ask the University Health Service (UHS) to review relevant health-related information, some of which may have to be provided by the student. The director of UHS (or his or her designee) will make a recommendation to the school regarding the appropriateness of allowing the student to take a medical leave of absence. The recommendation will be based on the seriousness of the health problem and the extent to which the health problem has interfered with the student’s coursework. Evidence of both is required.

The school will make the decision concerning the medical leave petition and will inform the student of that decision, including the effective date of the leave and any other conditions attached to it that are deemed appropriate to the circumstances of the particular case. Such conditions may include, for example, minimum and/or maximum length of time of the leave and/or requirements that must be met before the student can return from leave. Except in unusual situations, as determined by the school in its sole discretion, the petition to go on leave for medical reasons must be initiated by the student before the end of the semester in question.

A student who wishes to return from a medical leave of absence must petition the student’s school. The school will then
ask the UHS to review relevant health-related information, some of which may have to be provided by the student. The director of UHS (or his or her designee) will make a recommendation to the school regarding the appropriateness of allowing the student to return from medical leave of absence. The recommendation will be based on evidence that the medical condition that required the leave is controlled sufficiently to allow the student to make a successful return.

The school will consider that recommendation and whether any conditions imposed on the leave have been met, will decide on the student’s return, and will inform the student of its decision.

Except in unusual situations, as determined by the school in its sole discretion, the petition to return from medical leave of absence must be initiated by the student at least two and preferably three months before the expected date of return.

Students must register for “985: leave of absence” each semester they are in this category and must pay the designated fee. It should be noted that registration of “985: leave of absence” does count toward the degree time limit.

Involuntary Medical Leave of Absence
The University of Rochester provides a wide range of services to support and address the mental and physical health needs of students including assessment, short-term care as appropriate, and referrals. Our first concern is for the health and welfare of each individual in our community. Our goal is to enable all of our students to participate fully as members of Rochester’s academic community.

Students with psychiatric, psychological, or other medical conditions who pose a threat to themselves or others, or who disrupt the educational activities of the University community, may be required to take a leave of absence from the University. Under these circumstances, students will be given the opportunity to take a voluntary leave. However, if a student declines to take a voluntary leave, the University may determine that the student’s health and welfare, or the needs of the community, require a period of involuntary leave. The following policy establishes the protocol under which an involuntary leave of absence may occur and the process for return from such a leave.

The University may place a student on an involuntary leave of absence or require conditions for continued attendance when the student exhibits behavior associated with a psychological, psychiatric, or other medical condition that harms or threatens to harm the health or safety of the student or others; causes or threatens to cause significant property damage; or significantly disrupts the educational and other activities of the University community.

When a student exhibits any of the behaviors described above, the matter may be brought to the attention of the school associate dean of graduate studies (or designee). The associate dean of graduate studies (or designee) may place a student on an involuntary leave of absence or impose conditions upon the student’s continued attendance. The associate dean of graduate studies (or designee) will seek an immediate assessment of the student’s psychological, psychiatric, or other medical condition from the University Counseling Center (UCC), University Health Services (UHS), or from other appropriate professionals regarding the student’s circumstances.

The student will be notified that the associate dean of graduate studies (or designee) is seeking to determine whether he or she should be required to take a leave of absence. When reasonably possible, the student will be given the opportunity to confer with the associate dean of graduate studies (or designee) and to provide additional information for consideration.

The associate dean of graduate studies (or designee) will conclude the review of available information with a decision that may include the following:

- The student remain enrolled with no conditions;
- The student remain enrolled subject to conditions (including a description of those conditions); or
- The student be placed on an involuntary leave of absence.

If the associate dean of graduate studies’ (or designee’s) decision is to require an involuntary leave of absence, the decision will also indicate the length of the leave and describe the conditions (if any) under which the student may seek to return from leave. The student will then be withdrawn from active status by the associate dean of graduate studies.

The student shall be informed in writing by the associate dean of graduate studies (or designee) of the leave decision, the effective date of the leave, and conditions for return (if applicable). If a student is permitted to remain enrolled subject to conditions, the student shall be informed in writing of the effective date and the duration of the modified attendance.

Process for Return from Involuntary Medical Leave
A student seeking a return from leave must meet the conditions specified by the associate dean of graduate studies (or designee). The student must apply in writing to the associate dean of graduate studies. It is the responsibility of the associate dean of graduate studies to review the student’s compliance with specified conditions for the return from leave and to advise other University offices accordingly. Appropriate administrative duties with respect to commencing this leave process and maintaining its records will be the responsibility of the associate dean of graduate studies.

Confidentiality Regarding Medical Leave
All records concerning involuntary leaves of absence will be kept in accordance with the University confidentiality policy and other applicable policies. No statement regarding the leave of absence or withdrawal appears on the student’s official transcript.

Withdrawal from a Degree Program
The continuance of each student upon the rolls of the University, the receipt of academic grades, and the conferring of any degrees or the granting of any certificate are strictly subject to the discretionary powers of the University. Each student concedes to the University the right to require his or her withdrawal at any time for just cause.

Voluntary withdrawal from the University by a student who has not completed the degree program should be reported in writing by the student to the appropriate associate dean of graduate studies.
Readmission and Rematriculation after Withdrawal

Students who have withdrawn from work toward a graduate degree may apply for readmission. If readmitted, the student will be expected to reformulate a graduate program with the assistance of the faculty advisor and will be required to pay the stated rematriculation fee plus any other indebtedness previously incurred. Graduate courses completed successfully by the student prior to withdrawal may be counted as partial fulfillment of the requirements of the degree, provided:

A. the courses form an integral part of the student's new program and are approved for inclusion by the faculty advisor; and

B. the courses were completed not more than five years prior to the date of application for rematriculation.

The maximum time for a rematriculated student to complete the program for the degree will be based on the credit hours remaining to be completed, computed at a rate of at least six credit hours a year. This does not negate the maximum time limit for the degree.

Continuing Registration in Master's or PhD Dissertation Phase

All students must maintain continuous enrollment. If enrollment has been allowed to lapse, students must pay the appropriate fees for unregistered semesters in order to complete the degree.

MS, MA, or PhD students who have completed all credit requirements but not yet completed the final dissertation may register, with the approval of the advisor and the associate dean of graduate studies, for one of the categories below.

999/899

This status is utilized as follows:

- It is considered full-time enrollment for all reporting purposes and satisfies government requirements for F-1 and J-1 international students to maintain full-time enrollment.
- It is for students who are not enrolled in full-time coursework but are, nonetheless, working full time on their degree requirements (e.g., dissertation, thesis, degree recital, etc.).
- It includes a relevant fee (often a dissertation fee), as well as other fees associated with full-time enrollment.
- Students are registered with specific reference to a faculty advisor, who is ultimately responsible for monitoring their full-time effort.
- The student has either completed all requirements for the degree other than the thesis or is enrolled in final coursework in addition to the work necessary for the degree requirements (e.g., dissertation, degree recital, etc.).
- The student has actively demonstrated full-time effort, whether through being physically located on campus or having completed the appropriate petitions to demonstrate full-time effort elsewhere in the U.S. (999A/899A) or abroad (999B/899B).
- Mandatory Health Fee is not required if the student is studying in absentia (e.g., 999A/899A) and the student is not enrolled in the University health insurance.
- International students utilizing the in absentia options must coordinate with ISO for immigration purposes.
- Students are eligible for federal loans.
- Students are eligible for University health insurance.

998/898

This status is utilized most often by the Warner School and can be applied as follows:

- It is considered part-time (at least half-time) enrollment for all reporting purposes.
- This dissertation category does not satisfy government requirements for F-1 and J-1 international students to maintain full-time enrollment and will require that students obtain advanced permission for a Reduced Course Load, if eligible.
- It is for students who are not enrolled in half-time coursework but are, nonetheless, working at least half time on their degree requirements (e.g., dissertation, thesis, degree recital, etc.).
- It includes a relevant fee (often a dissertation fee).
- Students are registered with specific reference to a faculty advisor, who is responsible for monitoring their part-time effort.
- The student has either completed all requirements for the degree or is enrolled in final coursework in addition to the work necessary for degree requirements (e.g., dissertation, degree recital, etc.).
- Students are eligible for federal loans.
- Students are not eligible for University health insurance.

997/897

This status is utilized as follows:

- It is considered full-time enrollment for all reporting purposes and satisfies government requirements for F-1 and J-1 international students to maintain full-time enrollment.
- It is for students who are not enrolled in full-time coursework but are, nonetheless, working full time on their degree requirements (e.g., dissertation, thesis, degree recital, etc.).
- It does not include a relevant fee, though it does include other fees associated with full-time enrollment. The decision to utilize 997/897, and thus not charge fees, is made independently by each school and may occur for many reasons (for example, the student has not yet completed four full-years of doctoral enrollment, the student is enrolled full time during the summer, the student has been granted a one-time waiver of fees at the master’s level, etc.).
- Students are registered with specific reference to a faculty advisor, who is ultimately responsible for monitoring their full-time effort.
- The student has either completed all requirements for the degree other than the thesis or is enrolled in final coursework in addition to the dissertation.
• The student has actively demonstrated full-time effort, whether through being physically located on campus or having completed the appropriate petitions to demonstrate full-time effort elsewhere in the U.S. (997A/897A) or abroad (997B/897B).
• Mandatory Health Fee is not required for students studying in absentia (e.g., 997A/897A or 997B/897B) and not enrolled in the University health insurance.
• International students utilizing the in absentia options must coordinate with IS0 for immigration purposes.
• Students are eligible for federal loans.
• Students are eligible for University health insurance.

995/895
This status is utilized as follows:
• It is considered less than half-time enrollment for all reporting purposes.
• This category does not satisfy government requirements for F-1 and J-1 international students to maintain full-time enrollment and will require that students obtain advanced permission for a Reduced Course Load, if eligible.
• It is for students who are working less than half time on their degree requirements (e.g., dissertation, thesis, degree recital, etc.) or who are enrolled solely to satisfy the continuous enrollment requirement.
• It includes a relevant fee (often an enrollment continuation fee).
• Students are not necessarily registered with specific reference to a faculty advisor to monitor their effort. The choice to register with specific reference to a faculty advisor is made at the individual school level.
• Students are not eligible for federal loans.
• Students are not eligible for University health insurance.
• Though less than half time, this status does fulfill the requirement of continuous enrollment.

990/890
This status is utilized as follows:
• It is considered full-time enrollment for all reporting purposes and satisfies government requirements for F-1 and J-1 international students to maintain full-time enrollment.
• It is for students who are in full-time residence during the summer for purposes such as completing a dissertation, performing research, completing a clinical rotation, etc.
• Note that this status is different than using 997/897 for full-time summer enrollment. If the 4th, 5th, and 6th bullets of the 997/897 definition can be satisfied, a school may wish to use that status instead, to allow the student to be eligible for federal loans.
• It does not include a relevant dissertation fee.
• Students are not necessarily registered with specific reference to a faculty advisor to monitor their effort. The choice to register with specific reference to a faculty advisor is made at the individual school level.
• Students are not eligible for federal loans.
• Students are eligible for University health insurance.

Refund of the Semester or Quarter Fee in the Final Semester
When the final corrected copies of the dissertation are submitted, the student is eligible for a refund of the current fee for continuing enrollment according to the following schedule:
• 75% during the first calendar month of the semester or second three weeks of the quarter.
• 50% during the second calendar month of the semester or second three weeks of the quarter.
• 25% during the third calendar month of the semester or third three weeks of the quarter.

The form for refund is available in the Office of the University Dean of Graduate Studies for PhD students, and in the office of the associate dean of graduate studies for master’s students.

Conferral of Degrees
Degrees are awarded by the Board of Trustees at its regular meetings (October, March, and May) and conferred annually at the University’s Commencements. A degree candidate, upon meeting all degree requirements, will likely be awarded the degree at the next meeting of the Board of Trustees, but will receive the diploma at the following Commencement.

Transcripts
Transcripts of graduate work will be issued only at the written request of the student. Fees are determined at the school level. Transcript requests should be directed to the University registrar. (Students in the Eastman School of Music should request transcripts from the registrar, ESM.) The University reserves the right to withhold academic transcripts if an outstanding balance is owed the University.

Student Records
The University of Rochester complies fully with the provisions of the Family Educational Rights and Privacy Act (FERPA), 20 U.S.C. 1232g. Under FERPA students have, with certain limited exceptions, the right to inspect and review their educational records and to request the amendment of their records to ensure that they are not inaccurate, misleading, or otherwise in violation of the student’s privacy or other rights. Requests to inspect or review records should be addressed to the registrar, or to the appropriate administrator responsible for the record and will be honored within 45 days. Any student questioning the accuracy of any record may state his or her objection in writing to the University administrator responsible for the record, who will notify the student of his or her decision within 45 days of receiving the objection. Final review of any decision will be by the appropriate dean who, if requested by the student, will appoint a hearing committee of two faculty members and one staff member to investigate and make recommendations. Students concerned with the University’s compliance with FERPA have the right to file complaints with the U.S. Department of Education’s Family Compliance Office.
FERPA further requires, again with certain limited exceptions, that the student’s consent must be obtained before disclosing any personally identifiable information in the student’s education records. One such exception is disclosure to parents of dependent students. Another exception is disclosure to school officials with legitimate educational interests, on a “need-to-know” basis, as determined by the administrator responsible for the file. A “school official” includes anyone employed by the University in an administrative, supervisory, academic, research, or support staff position (including law enforcement unit personnel and health staff); any person or company acting on behalf of the University (such as an attorney, auditor, or collection agent); any member of the Board of Trustees or other governance/advisory body; and any student serving on an official committee, such as a disciplinary or grievance committee, or assisting another school official in performing his or her tasks. A school official has a legitimate educational interest if the official needs to review an education record in order to fulfill his or her professional responsibility. Other exceptions are described in the FERPA statute at 20 U.S.C. 1232g and regulations at 34 C.F.R. Part 99.

The University considers the following to be directory information: name, campus address, e-mail address, home address, telephone number, date and place of birth, academic fields of study, current enrollment (full or part time), dates of attendance, photographs, participation in recognized activities and sports, degrees and awards, weight and height of athletic team members, previous educational agencies or institutions attended, and other similar information. The University may publicize or respond to requests for such information at its discretion. However, the use of the records for commercial or political purposes is prohibited unless approved by the appropriate dean.

Currently enrolled students may request that directory information be withheld from disclosure by making a request, in writing, to the appropriate registrar. All requests made on or before September 30 will make it possible to have directory information omitted from printed directories. Requests made after this date should still be forwarded since they will prevent directory information from being released in the future. The University assumes that failure on the part of the student to specifically request the withholding of any directory information indicates approval of disclosure.

Established Interdisciplinary PhD Programs
For an established formalized interdisciplinary program (e.g., Visual and Cultural Studies, Neuroscience), a standing committee of faculty with formal affiliation to that program acts as a “department” and supervises the program requirements for its students.

Ad Hoc Joint PhD Degree Programs
To enable a student to pursue an individualized program of PhD study in more than one field, departments and programs authorized to offer work leading to the PhD degree may cooperate to offer a joint program. Joint work is supervised by an ad hoc committee convened for each student. One member of the ad hoc committee must be from outside the two programs of study.

Each ad hoc committee is appointed by the University dean of graduate studies upon nomination by the Graduate Committee of the school(s) in which the departments/programs are located. A proposal outlining how degree requirements will be met, along with supporting documentation (including program of study, proposed plan for qualifying examination(s), up-to-date advising record, proposed thesis topic) must be submitted for approval before the student is admitted to candidacy.

University Administration of PhD Programs
Each school of the University has a Committee on Graduate Studies or the equivalent, consisting of representatives of departments and programs offering graduate degrees. The duties of these committees include reviewing the administrative practices of the departments/programs and the school with respect to requirements and training for the PhD, and advising the associate dean of graduate studies about the work toward the PhD degree.

The University has a Council on Graduate Studies composed of
• representatives of departments and programs in the University authorized to offer the PhD degree;
• the deans or associate deans for graduate studies of each school, or officer whose duties most closely correspond to this role;
• the Provost of the University;
• the University dean of graduate studies, who serves as chair.

The principal functions of the Council are
• to decide on the basis of quality considerations which departments shall be authorized to give work towards the PhD degree, and to authorize or restrict, as necessary, the different PhD programs.
• to scrutinize the policies, standards, and facilities for work for the degree of Doctor of Philosophy throughout the University to ensure a minimum quality standard is met, and to make reports on the findings and recommendations to the Provost and President. In performance of this function, the council may engage scholars from other universities.
• upon nominations by the faculties or other authorized agencies in the several schools, to recommend to the Provost for transmission to the Board of Trustees the candidates for the Doctor of Philosophy degree.
A Steering Committee of the Council, composed of the University dean of graduate studies and the dean or associate dean of graduate studies (or equivalent) of each school, advises the Council in the performance of its functions, exchanges information, and adjusts procedures in the schools to enable administrative uniformity as needed.

The vice provost and University dean of graduate studies is appointed by the trustees on recommendation of the provost and president. The vice provost and University dean of graduate studies

- is the University spokesperson in matters of graduate studies
- presides at meetings of the Council and the Steering Committee
- may serve ex officio as a member of the committee established in any school for the conduct of the MA, the MS, or the PhD degree
- appoints (upon the advice of each associate dean of graduate studies) all committees for the final oral examination for the PhD degree
- the University dean of graduate studies or a delegate presides at all such examinations as chair.

Admission to PhD Programs

No person holding a full-time appointment as assistant professor or higher at the University of Rochester may be awarded an earned degree of Doctor of Philosophy from this University. An exception to this rule may occur only if the faculty member’s appointment is in a department other than the one in which the degree is earned and only if that appointment is warranted by the completion of a separate Doctor of Philosophy or other appropriate graduate degree. Faculty members holding the rank of instructor and non-faculty full-time employees of the University may pursue studies leading to the degree of Doctor of Philosophy only by special permission of the appropriate school’s Committee on Graduate Studies.

Transfer Credit

Work taken prior to matriculation in a graduate degree program is classified as possible transfer work. Limits on transfer credits are set at the program level. Credit hours may be accepted toward degree requirements if the subjects taken form an integral part of the proposed program of study and if taken within five years of the date of matriculation with a grade of B or higher as interpreted in this University. Requests for transfer credit must have the approval of the associate dean of graduate studies. Similarly, permission to take work at another institution for transfer credit after matriculation in a graduate program must be approved in advance by the associate dean of graduate studies.

Full-Time Residency Requirement

A minimum of one year (two consecutive semesters, excluding summers) in residence while enrolled as a full-time student is required. Doctoral Dissertation (“999”) may not be used to meet the one-year residency requirement. Further requirements may be completed by full-time residence either during the academic year or during the summer. Departmental/program requirements, however, may necessitate continuous residence until work for the degree is completed.

Part-Time Study

Ordinarily, graduate students may pursue work leading to the degree Doctor of Philosophy only if they are full-time students.

Permission to pursue a part-time plan of study is at the option of the department/program, subject to the approval of the Committee on Graduate Studies of that school. Part-time plans of study are subject to the following restrictions:

1. under no conditions will the residency requirement described above of one continuous academic year of full-time study be waived,
2. the minimum registration will be two courses, each carrying at least three credit hours, per calendar year (however, departments/programs may establish a higher minimum registration requirement), and
3. a student receiving grades lower than B (or S) in more than one-quarter of the courses for a given academic year may not be permitted to continue in the part-time program.

Time Limit for PhD

All work for the PhD, including the final oral examination, must be completed within seven years from date of initial registration, except that a student who enters with a master’s degree or its equivalent for which the full 30 credit hours is accepted in the doctoral program must complete all work within six years from date of initial registration. All registration categories, including "985: Leave of Absence," count towards the time limit.

Students who for good reasons have been unable to complete a program within the above stated limits may, upon recommendation of the faculty advisor and the department chair/program director, petition the associate dean (in the School of Nursing, the PhD subcommittee) for an extension of time. Such extensions, if granted, will be of limited duration and must be reapproved at least annually. Requests for extensions beyond 12 years must be approved by the University dean of graduate studies.

Program of Study

At least 90 credit hours of study beyond the bachelor’s degree or 60 hours beyond an acceptable master’s degree are required. The associate dean of graduate studies may approve, for students who do not present the master’s degree, up to 30 credit hours of acceptable graduate work taken at this or another university toward the requirements for the doctoral degree (see section on Transfer Credit).

A tentative program of study leading to the degree of Doctor of Philosophy must be prepared by the student in consultation with his or her advisor. This should be done within two years after initial registration for doctoral studies. This program must include the following:

- A list of those courses for which the student must receive graduate credit. Other courses deemed desirable but not essential need not be listed.
• The specific foreign language(s), if any, in which the student must show competence (see below).
• The dissertation title if known, or area of study in which the dissertation is expected to be written.
• Name of the research director.
  The program of study must be approved by the department chair/program director or a designated representative and then transmitted to the associate dean of graduate studies for approval. Changes in a student’s program are made by the same procedure.
  The program of study will constitute the formal requirements that must be met by the student before completion of work for the degree.
  Credit hours used for two graduate degrees cannot be used for another graduate degree at the University.

Foreign Language Requirements
Subject to the approval of the appropriate Committee on Graduate Studies, each department/program may designate its foreign language requirements for the PhD degree and specify the method of testing. Specific language requirements may be set for individual students by the department/program, subject to review by the associate dean of graduate studies. Each student should consult with his or her advisor concerning language requirements.

The basic language requirement, if any, must be met before the candidate may be permitted to take the qualifying examination.

Qualifying Examination
All PhD programs must administer a qualifying examination as part of the PhD program requirements. The qualifying examination may be either written or oral or both, at the discretion of the department/program, and must be passed at least six months before the final examination may be taken. The Committee to conduct a qualifying examination will be appointed by the appropriate associate dean and will consist of at least three full-time faculty of professorial rank (four for the School of Medicine and Dentistry). Subject to the approval of the appropriate Committee on Graduate Studies, each department/program may designate whether or not it will include a member from another department/program on the committee. A vote to pass the candidate must be approved by a majority of the designated members of the committee. The votes of all committee members will be recorded. The office of the associate dean must be notified at least two weeks before a qualifying examination is to be held, and passage or failure must be reported within one month after the examination. After a failure, a second qualifying examination may be taken if in accordance with program policy. A third examination may be taken only upon the recommendation of the appropriate Committee on Graduate Studies and with the approval of the associate dean or equivalent. In the School of Nursing and the School of Medicine and Dentistry, a third examination will not be given.

Admission to Candidacy
When the associate dean of a school certifies that a student has passed the qualifying examinations and is recommended for candidacy, it is assumed that the student is a candidate for the PhD degree. Upon request, the University dean of graduate studies may issue a certificate attesting to this fact.

PhD Dissertation
Dissertation Advisory Committee
Ordinarily no later than when a student has been admitted to candidacy, the department chair or program director approves an advisory committee for the dissertation. The committee should meet the requirements for the final oral examination committee described below. The composition of the dissertation advisory committee should be reported to the associate dean.

It is the responsibility of the dissertation advisory committee to advise the student concerning the proposed research and thesis, consult with him or her at appropriate stages in the research, and ordinarily to serve on the final oral examination committee.

Upon recommendation of the faculty of the student’s department/program and the associate dean of the school involved, the University dean of graduate studies may approve a person other than a full-time University of Rochester faculty member (e.g., a senior research associate or an adjunct or part-time faculty member) to serve as the student’s faculty advisor or research director. Approval must be obtained in writing.

In some circumstances, it may be appropriate to appoint to the advisory committee a person other than a member of the faculty of the University. With the approval of the associate dean and the University dean of graduate studies, this person may serve in place of or in addition to the outside department faculty member. Approval must be obtained in writing.

Preparation of Dissertation
A dissertation is required of each candidate for the degree Doctor of Philosophy. The dissertation research must be conducted and the dissertation written under the supervision of the main advisor or research director, regardless of the student’s residency status.

The dissertation must be an original critical or synthetic treatment of a suitable subject, an original contribution to creative art, or a report on independent research formulated in a manner worthy of publication.

The dissertation must be written in English except where the subject matter demands otherwise and when requested by the department chair/program director and approved by the associate dean of graduate studies. The Preparation of Doctoral Theses: A Manual for Graduate Students must be followed to prepare the dissertation. Copies are available from the Office of the University Dean of Graduate Studies, associate deans’ offices, departmental offices, or the University’s website: www.rochester.edu/theses.

The dissertation must be approved by the research supervisor before the candidate may take the final oral examination.

Disclosure of Collaboration, Financial Support, and Prior Publication
All dissertations must include a section entitled “Contributors and Funding Sources.” Placement of this section in the dissertation is described in the Thesis Manual.
In this section, all collaborations with others in carrying out the dissertation research must be clearly described, and the student’s independent contributions must be made clear. Similarly, the sources of financial support for the research must be listed.

Students who completed all work independently and/or without outside funding support should indicate this in the required section.

If content or results from the dissertation have been published in full or in part, the biographical sketch section of the dissertation must include bibliographic information about those publications. The dissertation will not be approved if it is subject to governmental or other restrictions that limit freedom of publication.

Final Oral Examination for the PhD Degree

Final Oral Examination Committee

The committee for the final examination for the PhD degree is appointed by the University dean of graduate studies on the advice of the appropriate associate dean of graduate studies. The committee shall consist of:

- At least two current full-time tenure-track members with the rank of assistant professor or higher who hold their primary appointments in the department offering the degree program, or are among the core faculty defined for an interdisciplinary PhD program, in the role of “inside members.” The dissertation advisor or supervisor may or may not hold a primary appointment in the department offering the candidate’s degree program but is considered to be inside that department or program for the purpose of committee membership. The advisor must be present for the examination.

- At least one current full-time faculty member at assistant professor rank or higher from outside the department offering the degree program or not a core member of the interdisciplinary degree program faculty, in the role of “outside reader.” The holder of a secondary appointment in the department offering the candidate’s degree program may serve as the outside member, provided that his or her primary appointment is in another department. A committee made up of faculty members whose primary appointments are all in the same department will not be permitted.

Exceptions to the above must be approved in writing, as described in the Dissertation Advisory Committee section above.

The University dean of graduate studies may appoint no more than one guest member, with vote, to any PhD final examination when requested by the program director or chair of the department concerned. The guest member may either replace or be in addition to the usual outside reader.

Such guest members shall be recognized experts in the field of the dissertation, but not necessarily members of a university faculty. A guest member who is not a current or former faculty member of the University must be approved by the University dean of graduate studies prior to the dissertation being registered. A request to the University dean of graduate studies must include a curriculum vitae and must have been approved by the associate dean of graduate studies in the relevant school.

In addition to the members of the examining committee, other persons may attend the closed portion of PhD final examinations with the approval of the University dean of graduate studies. These visitors shall not participate in the questioning and must leave before the committee votes.

Registering the PhD Dissertation for the Final Oral Examination

A candidate may proceed with registration of the dissertation only after receiving written permission of the advisor of the dissertation. The dissertation will not be accepted for registration if the candidate is not registered for the current semester/quarter.

The dissertation must be submitted to the office of the associate dean of graduate studies in the appropriate school to be processed and then delivered to the Office of the University Dean of Graduate Studies for registration.

The final oral examination cannot be held until at least 15 full working days have elapsed after the dissertation has been registered in the Office of the University Dean of Graduate Studies. The University dean of graduate studies’ deadline of 15 full working days may be increased to 20 full working days during the summer.

The dissertation is not considered registered until it arrives in the Office of the University Dean of Graduate Studies. Therefore, the department and/or school deadline may be in advance of the University dean of graduate studies’ deadline. It is the student’s responsibility to plan accordingly. The student should check with the office of the associate dean of graduate studies for established deadlines.

It is the responsibility of the candidate to submit the completed dissertation in final form to the office of the associate dean of graduate studies in the appropriate school by the school’s deadline. The dissertation must be bound in some manner and submitted together with the required paperwork, including the appointment form which states the departmental recommendation for members of the examining committee, and the date, time, and place of the examination. All typographical, spelling, and grammar errors must be corrected before the dissertation is submitted for registration. A “final draft” with numerous errors to be corrected after the defense is not acceptable.

The candidate must distribute copies of the dissertation to members of the final examination committee before or at the same time the dissertation is registered, or the examination will be canceled. Once the dissertation has been registered and copies distributed to committee members, no further changes can be made until after the final oral examination or the examination will be canceled.

Final oral examinations for the PhD degree may be scheduled by the normal procedure during the summer according to the PhD calendar. No final examinations can be held during the blackout periods listed in the PhD calendar established by the Office of the University Dean of Graduate Studies.

Final Oral Examination (PhD Dissertation Defense)

The final oral examination will be taken after completion of all other requirements for the degree but not earlier than six months after the qualifying examination. The final oral examination committee is presided over by the University dean of graduate studies or an appointed representative, who serves as chair.
The final oral examination for the Doctor of Philosophy degree must be taken at this University. The student, the advisor, and the appointed chair must be physically present. Participation of others via videoconference is permitted only if approved in advance by the advisor, the associate dean of graduate studies, the appointed examination chair, and the University dean of graduate studies.

The final oral examination will include the subject covered by the dissertation and the field in which the dissertation is written, with particular attention to recent and significant developments in that field. The purpose is to ascertain whether or not the candidate has proposed a significant thesis in the dissertation and whether or not he or she has defended the dissertation adequately by offering appropriate and effective arguments and by marshaling relevant and convincing evidence.

The presentation and defense of a significant dissertation is the capstone of the work for the PhD degree. All other work toward the degree is preliminary to this presentation. The final oral examination results not only in a judgment on a single work of scholarship but also implicitly on the quality of the whole graduate education of the candidate. Because the final oral examination has this wider meaning, it is important that the committee satisfy itself that a significant thesis has been successfully defended.

A vote of approval of the final oral examining committee must be unanimous, but in the case of a single dissenting vote the case will be presented for decision to the University Council on Graduate Studies. A candidate who fails the final examination shall be allowed one repeat examination, unless the examining committee recommends against it by a majority vote. Regulations for committee structure, timing of registration before defense, and so forth for a repeat examination are the same as those applied to the initial examination.

Submission of Final Dissertation
Following successful completion of the final oral examination, the candidate completes final revisions, secures approval of those revisions if so specified at the defense, uploads the final copy to the UMI/ProQuest website, and notifies the Office of the Dean of Graduate Studies that this process is complete. The candidate also should provide paper copies for use of the school or department if required.

Each PhD student is also required to submit a completed authorization form for inclusion of the dissertation in UR Research (the University’s digital research repository). Further instructions along with the authorization form will be given to the student at the final oral examination.

University Policies Concerning the MA and MS Degree

Administration of Master of Arts and Master of Science Degrees
The master’s degree is awarded in arts, science, music, engineering, nursing, business, and education. Certain policies for MA and MS degree programs are common across programs and are detailed in this Bulletin. All administration of work for master’s degrees and recommendation of candidates for these degrees is vested in the associate dean of graduate studies and the Committee on Graduate Studies in each school.

Program of Study
Each full-time master’s student must submit a proposed program of study to the associate dean of graduate studies before the end of the second term. Each part-time master’s student must submit a proposed program of study upon the completion of 9 or 12 hours of graduate credit or as determined by the school.

The program of study, to be formulated with the assistance of the faculty advisor and approved by the associate dean, is expected to form a consistent plan of work pursued with a definite aim. Courses in another department closely related to, but outside the student’s major field of interest should not ordinarily exceed 12 hours of credit, and the candidate must have had thorough undergraduate preparation for such work. The program must include at least 20 hours taken at the University of Rochester as a matriculated student in a graduate degree program. Other than in approved combined undergraduate-graduate degree programs, no course completed before the candidate has received the bachelor’s degree may be included in the graduate program.

Two plans of study are available to students working for most MA and MS degrees; the principal difference between them is that under one plan (Plan A) a dissertation is required, while under the other (Plan B) a dissertation is not required, but in most departments a comprehensive examination must be passed.

Students may not switch from Plan A to Plan B (or vice versa) without written approval from the associate dean of graduate studies.

A minimum of 30 semester hours of correlated work of graduate character is required, at least 12 of which must be at the 400 level or higher, together with such other study as may be necessary to complete the student’s preparation in the chosen field and bring it to the required qualitative level. Minimum requirements are determined by the department/program concerned, with the approval of the associate dean of graduate studies.

Transfer Credit
Work taken prior to matriculation in a graduate degree program is classified as possible transfer work. Transfer credit may be accepted toward degree requirements if the subjects taken form an integral part of the student’s proposed program of study and if taken within five years of the date of matriculation with a grade of B or higher as interpreted in this University. Requests for transfer credit must have the approval of the faculty advisor and the associate dean of graduate studies.

The number and type of credit hours acceptable as transfer credit for work previously taken at the University of Rochester or another university is determined at the school level. Credit hours used for two graduate degrees cannot be used for another graduate degree at the University.
Permission to take work in another institution for transfer credit after matriculation in a graduate program must be approved in advance by the associate dean of graduate studies.

Part-Time Study
Students admitted to master’s degree programs on a part-time basis must follow continuous programs of study. The associate dean of graduate studies may disapprove a part-time program if the nature of the proposed study makes such a program advisable.

Time Limit for MS or MA Degree
A candidate must complete all the requirements for the master’s degree within five years (seven years at the Simon School) from the time of initial registration for graduate study, and must maintain continuous enrollment for each term after matriculation. Except in the School of Nursing, the five-year maximum period will be reduced at the rate of one term for each unit of three hours taken prior to matriculation at this University and applied toward the requirements for the master’s degree. All registration categories including “Leave of Absence” count towards the time limit.

Students who for good reason have been unable to complete a program within five years may, upon recommendation by the faculty advisor and department chair, petition the associate dean of graduate studies for an extension of time. Such extension, if granted, will be of limited duration.

Requirements for the MA or MS Degree under Plan A
Plan A requires the writing of a dissertation and the passing of an oral examination on the dissertation.

Program of Study for Plan A
A dissertation is required in each program for the Master of Arts or Master of Science degree under Plan A. The dissertation and the research upon which it is based represent a minimum of 6 and ordinarily a maximum of 12 credit hours in reading or research. In certain cases, and with the prior approval of the associate dean of graduate studies, the credit for dissertation research may exceed 12 hours.

Preparation of MS or MA Dissertation
The dissertation must show independent work based in part upon original material. It must present evidence that the candidate possesses ability to plan study over a prolonged period and to present in an orderly fashion the results of this study. The dissertation should display the student’s thorough acquaintance with the literature of a limited field.

“Preparing Your Thesis: A Manual for Graduate Students” is also used to prepare master’s dissertations. Copies of the booklet are available from the office of the associate dean of graduate studies or on the University’s website: www.rochester.edu/theses.

Registration of MS or MA Dissertation
The dissertation must be registered with the office of the associate dean of graduate studies and copies given to the members of the examining committee at least one week prior to the oral examination (two weeks in the School of Medicine and Dentistry). The final examination must be held prior to the date set by the associate dean of graduate studies.

Submission of Copies
The school or program may require printed and/or electronic copies of the final thesis as a condition of completion of the degree program.

Final Oral Examination for MS or MA under Plan A
Each candidate must pass a final oral examination before a committee of at least three members of the faculty appointed by the associate dean of graduate studies (four for the School of Medicine and Dentistry). One member will be from a department other than that in which the student has done the major portion of the work. No candidate may appear for the final examination until permission is received from the faculty advisor to proceed. The examination will not be given until at least a week has elapsed after registration of the dissertation. The final examination may be preceded by other examinations, oral or written, as designated by the department/program or school concerned.

Re-Examination
A student who fails the final oral examination may request re-examination not less than four months later. No student will be allowed to take the examination a third time without a recommendation from the department/program in which the major work was done and the approval of the Committee on Graduate Studies of the school.

Requirements for the MA or MS Degree under Plan B
Program of Study for Plan B
The degrees Master of Arts and Master of Science under Plan B are awarded for successful completion of at least 30 hours of graduate credit, or more if required in the student’s program of study. At least 18 hours of the coursework must be in the student’s principal department, except for interdisciplinary programs which have been approved by the relevant school’s Committee on Graduate Studies, and at least 12 of the 18 hours in the approved program must be in courses numbered 400 or over. Individual schools may set higher requirements. If the department requires a course of directed individual study leading to the writing of a master’s essay, this course is in addition to the minimum requirement of courses numbered 400 or over. It may carry up to four hours of credit.

Ordinarily, research credit is not part of a Plan B master’s program; but, with the approval of the associate dean of graduate studies, up to six hours of research credit may be granted. Total credit for research, reading, and the master’s essay may not exceed six hours. Credit hours used for two graduate degrees cannot be used for another graduate degree at this University.
Directed Study for the Master’s Essay
The master’s essay, required by some departments/programs, must present evidence of the student’s ability to present a well-organized report on a topic of significance in the field. The writing of this essay is under the supervision of one member of the student’s principal department/program, and must be approved by one additional member designated by the chair of the department or by the program director for interdisciplinary programs.

Comprehensive Examination
Most Plan B programs of study require a comprehensive examination in the field of specialization. It may be written, oral, or both, and is conducted by at least two faculty members.

Students failing the general examination may be allowed to take another examination during the following semester but not later than one year after the original examination. More than one repetition of the examination is not permitted.

Standards of Conduct for Graduate Students

The University as a Community
The University of Rochester is dedicated to providing educational opportunities for its students and to transmitting and advancing knowledge. The tradition of the University as a sanctuary of academic freedom and a center of informed discussion is an honored one. It is committed to the protection of intellectual freedoms and rights: of professors to teach; of scholars to study; of students to learn; and of all to express their views.

The University of Rochester is pluralistic and values diversity. Members of the community must respect the rights of the individuals and diverse groups that constitute the University. It is essential that the University remain supportive of democratic and lawful procedure, dedicated to a rational approach to resolving disagreement, and free from discrimination, violence, threats, and intimidation.

Students are expected to abide by the rules of the University and to conduct themselves in accordance with accepted standards of good citizenship, honesty, and propriety, and with proper regard for the rights of others. Students must also obey federal, state, and local laws as would any good citizen. Furthermore, their responsibilities as students, scholars, researchers, and in many cases teachers and emerging professionals, often make special demands for the highest ethical standards.

The maintenance of harmonious community standards requires that behavior that interferes with or threatens the welfare of others or the University community be prevented. Ignorance of these standards will not be considered a valid excuse or defense. Student participation in any unlawful or other potentially serious violations of University policy may lead to suspension or expulsion from the University.

Basic Rights and Expectations of Students

Accused of Misconduct
Students who choose to attend the University of Rochester should understand that they have certain fundamental rights and that they have committed themselves to adhering to academic and social standards essential to the well-being of the community. Any student charged with misconduct will be treated in accordance with the basic standards of fundamental fairness, which include timely notification of charges, fair and impartial hearings, and the right of appeal. Students are expected to respond in a timely fashion to any and all written or verbal communication, including but not limited to voice mail, electronic mail, letters, and other forms of correspondence. Failure to check for these forms of communication does not relieve students of their responsibility to reply.

A significant goal of campus judiciary proceedings is to promote the welfare of the student, making the student aware of community standards, and discouraging the student from engaging in behavior that negatively impacts the University community. Another significant goal is to protect the University community’s collective interests and deter potential offenders.

There are important technical differences between campus and criminal judicial proceedings. The University of Rochester, in contrast to the state, does not have fully empowered police or investigative units, does not have legal counsel in preparing or presenting cases, and has limited capabilities in comparison with the state to subpoena witnesses or punish them for perjury. It would not be in either the University’s or the student’s best interest to attempt to incorporate these features in the campus judicial system. Indeed, a formal and adversarial procedure might have the effect of suppressing information that, in the interest of a student’s long-term development, is best to bring out.

University Procedures and the Public Law
The University is not a sanctuary from public law and does not promote or condone unlawful behavior. The University cooperates with law enforcement authorities in a manner consistent with its legal duties and the interests of the University community.

Students under prosecution for violation of public law may also be subject to University judicial proceedings, which are independent of those under public law. The University may take prompt action under its own procedures regardless of whether the public officials have disposed of the case or what disposition they make.

Students may be subject to the University conduct system for allegations of unlawful conduct that occur on University property or that occur off campus if such off-campus conduct is associated with a University activity or raises considerable concerns that the individual or group poses a threat to the safety or welfare of the University community.

Any student accused of misconduct will be treated in accordance with standards of fundamental fairness as explained on pages 43–44.

Jurisdiction and Responsibility for Academic and Nonacademic Misconduct
A complaint against a graduate student should be forwarded to the appropriate associate dean of graduate studies within that student’s school, who determines whether the complaint should be treated as an academic or a nonacademic matter. Academic matters will be referred to the appropriate associate dean, as ...
explained on pages 36–38. Nonacademic matters will be referred to the judicial officer, who will consult with the associate dean before going forward with any complaint against a graduate student that he or she receives from any source other than the associate dean.

There is not always a clear distinction between academic and nonacademic misconduct. The fundamental criterion for deciding whether a matter is academic or nonacademic is whether the student was acting in a scholarly or professional capacity. When the incident involves a student acting in his or her role as a student, teaching assistant, or expert in his or her discipline, then the matter is an academic matter. When the incident involves a student acting as an individual independent of these roles, then the matter is nonacademic. The available hearing procedures are not intended to be mutually exclusive; it is possible that a student could be subject to both academic and nonacademic discipline for the same misconduct.

Jurisdiction over cases of academic misconduct involving graduate students has been delegated to individual department hearing panels who, in consultation with the associate dean of graduate studies, make findings and submit recommendations to the University dean of graduate studies. Details of this process are provided below.

In cases of nonacademic misconduct, authority to hold students accountable through the conduct system (which the University considers to be any person or group who is or was in attendance during an academic period in which misconduct occurred or between academic periods for continuing students) is vested in the president of the University by the University’s bylaws. This authority has been delegated through the dean of the college and dean of students to the judicial officer in the Office of the Dean of Students of the College (“the judicial officer”) for all nonacademic misconduct involving graduate students with a further delegation to conduct teams/officers.

These conduct teams/officers determine whether an alleged violation of the standards of the University community occurred by the preponderance of the evidence. If the team/officer finds that a violation did occur, it further determines the response which is most likely to benefit both the individual student and the larger University community. As the University official responsible for student conduct, the judicial officer receives the recommendation of these conduct teams/officers on behalf of the University, accepts or modifies the recommendation, and formally implements University action.

Discretionary responsibility for handling extreme cases, where such action is essential for maintaining the orderly processes of the University, is retained by the president or a delegate. The University also retains the right to interim suspend, ban, or otherwise constrain students if they pose a perceived threat to themselves or to the University community, including threats to their own physical or emotional safety and well being, the preservation of University property, or safety and order on University premises. Interim suspension, removal from housing, or other temporary restrictions may be imposed before, during, or after a hearing and any appeal process.

Other officers and agents of the University may promulgate rules and regulations applicable to students in particular situations independent of these procedures and guidelines. These officers and agents shall report serious violations of such rules and regulations to the judicial officer.

**Definition of Academic Misconduct**

The fundamental criterion for deciding whether a matter is academic or nonacademic is whether the student was acting in a scholarly or professional capacity. Misconduct involves a student acting in his or her role as a student, including activities as a research or teaching assistant, or expert in his or her discipline, then the matter is an academic matter.

**Academic Honesty Policy**

The University of Rochester considers academic honesty to be a central responsibility of all students. Suspected infractions of University policies will be treated with the utmost seriousness. Suspected graduate academic misconduct will be reported to the department chair and associate dean of graduate studies.

Plagiarism is a pervasive form of academic dishonesty. This is the use, whether deliberate or unintentional, of an idea or phrase from another source without proper acknowledgment of that source. The risk of plagiarism can be avoided in written work by clearly indicating, either in footnotes or in the paper itself, the source of any other major or unique idea which the student could not or did not arrive at on his or her own. Sources must be given regardless of whether the material is quoted directly or paraphrased. Another form of plagiarism is copying or obtaining information from another student. Submission of written work, such as laboratory reports, computer programs, or papers, which has been copied from the work of other students, with or without their knowledge and consent, is also plagiarism. In brief, any act that represents someone else’s work as one’s own is an academically dishonest act.

A second example of academic dishonesty relates to misuse of library materials. Any act that maliciously hinders the use of or access to library materials is academically dishonest and falls under the terms of this policy. The removal of pages from books or journals disadvantages others in the academic community. Similarly, the removal of books from the libraries without formally checking out the items, the intentional hiding of materials, or the refusal to return reserve readings to the library is dishonest and harmful to the community.

There are several other forms of academic dishonesty including, for example, obtaining an examination prior to its administration or using unauthorized aids during an examination. It is also academically dishonest to assist someone else in an act of academic dishonesty. Fraud, misrepresentation, forgery, falsifying documents, records, or identification cards, and fabricating or altering research data are other forms of academic misconduct.

A student remains responsible for the academic honesty of work submitted to the University as part of the requirements for the completion of a degree (or any other coursework taken at the University) even after the work is accepted, the degree is granted, or the student is no longer matriculated at the University of Rochester.

Ignorance of these standards is not considered a valid excuse or defense.
Academic Misconduct

If alleged academic misconduct involves sponsored research, threatens the integrity of the scientific method, or compromises the creation of new knowledge, the matter will be referred to and will follow the procedures outlined in the Policy on Misconduct, Scholarship, and Research in the Faculty Handbook.

Associate dean receives report of potential academic misconduct; reviews material and/or meets with those involved.

- Case dismissed
- Associate dean determines matter should be treated as academic misconduct
  - If alleged academic misconduct involves sponsored research, threatens the integrity of the scientific method, or compromises the creation of new knowledge, the matter will be referred to and will follow the procedures outlined in the Policy on Misconduct, Scholarship, and Research in the Faculty Handbook.
  - Informal or administrative resolution

Refers charges to student’s department

Department Hearing Panel conducts hearing, makes findings, presents recommendation to the dean or director who submits them along with his or her recommendation to the University dean of graduate studies

University dean of graduate studies issues decision and, if appropriate, a sanction

Student/Victim appeals decision to the provost

- Decision accepted
- Decision modified
- Decision upheld
Judicial Process for Academic Misconduct
As indicated in the diagram on page 37, charges of academic misconduct are referred to the student’s department by the associate dean. In a school without departments, these matters will be handled by the school. Each department, interdisciplinary program, or school will have a written policy on file with the associate dean to deal with these matters and a designated group called the Department Hearing Panel (Committee on Academic Integrity at Eastman) to hear the charge. The department may utilize one of several mechanisms for hearing charges of academic misconduct. These may include a panel that consists of (1) the usual faculty group that deals with graduate student business, (2) the entire faculty of the department, or (3) a committee appointed by the department chair specifically for the purpose of hearing the academic misconduct charge. A department’s written policy may also call for graduate student representation on the panel.

The Department Hearing Panel, in consultation with the associate dean and in accordance with the standards set forth in the section Fundamental Fairness above (to the extent appropriate to the circumstances—with the associate dean functioning as the “judicial officer” and the Department Hearing Panel as the “hearing team”) conducts a hearing, makes findings, and presents a recommendation to the appropriate dean or director. The dean or director then reviews the findings and recommendation, and submits them along with his or her recommendation to the University dean of graduate studies, who issues the final decision and sanction. An appeal may be made to the provost within seven days of the decision and will follow, to the extent feasible, the procedures set forth in the section Appeals below.

If either the department chair or the associate dean believes that the alleged misconduct in any way involves sponsored research (including federal training grants), threatens the integrity of the scientific method, or compromises the creation of new knowledge (including original art, scholarship, and research), the matter will be referred to and will follow the procedures outlined in the Policy on Misconduct in Scholarship and Research in the Faculty Handbook.

Definition of Nonacademic Misconduct
Students should conduct themselves in a way that reflects respect for the standards of our community; this includes obeying federal, state, and local laws as well as the guidelines listed below. Not knowing and understanding these standards is not a defense or valid excuse.

While this list is not intended to be exhaustive, some examples of how students might violate University standards and regulations follow:

1. Fraud, misrepresentation, forgery, falsifying documents, records or identification cards, fabricating research data, and plagiarism given to or received by a University official acting within the scope of his or her duties. This includes providing incomplete information regarding an investigation into alleged policy infractions.
2. Unlawful or improper use, manufacture, sale, distribution, or possession of alcohol as defined by University Alcohol and Other Drugs Policy.
3. Unlawful use, manufacture, sale, distribution, or possession of drugs, narcotics, controlled substances, and/or the paraphernalia* associated with such as defined by University Alcohol and Other Drugs Policy.
4. Possession, distribution, or use of items presenting an imminent or potential threat to the safety and well-being of others, including but not limited to the following:
   - weapons of any type (firearms, bb or pellet guns, knives, bows and arrows, stun guns, paint ball guns, and the like),† combustible materials such as gasoline or propane tanks
   - candles, incense, or other open flame or burning substances
   - operation of or tampering with fire safety apparatus for any purpose other than their intended and proper use
5. Disorderly conduct including
   - fighting, threats, assault, attempted assault, harassment, or other actual or attempted conduct which threatens the health or safety of yourself or another, or
   - noise violations or other actions which could reasonably be expected to compromise the unhindered pursuit of the University’s educational mission.
6. Obstruction, disruption, or noncooperation with a disciplinary hearing process, including perjury, and the failure to comply with an imposed response.
7. Failure to comply with any reasonable request of a University official acting within the scope of his or her duties.
8. Actual or attempted
   - theft to the property of the University or others, and/or
   - damage to the property of the University or others.
9. Unauthorized use or misuse of or entry into property or facilities
   - obstruction of or dangerous interference with the free flow of traffic on campus
   - leading or inciting the disruption of day-to-day activities of others on campus
   - misuse of University computers and computer systems and copyright infringement violations (see Computer Use Policies).

* Hookahs are frequently associated with drug use and are not permitted on campus without approval from the Center for Student Conflict Management. Students wishing to obtain approval must bring the hookah to 510 Wilson Commons during regular business hours. If approved, the student will be given a certificate, which must accompany the hookah at all times. Any unregistered hookahs are subject to confiscation by University Security and/or the University Fire Marshal’s Office. Students possessing unregistered hookahs will be documented.
† If a weapon is discovered, Security staff will confiscate it and turn the item over to the appropriate law enforcement agency. In cases where the term “weapon” is subject to interpretation, students are expected to comply fully with University Security staff directives. Possession of weapons may result in arrest and suspension and/or expulsion from the University.
10. Hazing, which may include actions taken or situations created which have the potential to produce mental or physical harm, discomfort, embarrassment, harassment, or ridicule to a reasonable person.

11. Sexual harassment, racial harassment, or any other form of illegal discrimination. This includes any form of unwanted sexual contact, including sexual assault. "Unwanted" means against a person's wishes or without consent, including those instances in which the individual is unable to give consent because of unconsciousness, sleep, impairment, or intoxication due to alcohol or other drugs. (See University Policy on Harassment and Discrimination and additional information regarding Sexual Assault below.)

12. Failure to consider community expectations and to demonstrate proper regard for the academic and personal rights of others. This includes complicity. The absence of active participation in misconduct is often an insufficient response to violations of the code of conduct. Students are expected to take an active role in disengaging themselves from all acts of misconduct and are expected to report serious acts of misconduct to appropriate authorities. Failure to do so can be considered acts of complicity and may result in that student's facing the same charges as active participants.

13. Any violation of the University's policies, rules, or regulations.

Additional Information on Certain Forms of Nonacademic Misconduct

Equal Opportunity Statement

This policy affirms the University of Rochester’s commitment to nondiscrimination, equal opportunity, and affirmative action in admissions, employment, and access to and treatment in University programs and activities, in accordance with federal, state, and local laws and regulations. (Titles VI and VII of the Civil Rights Act of 1964, as amended; Executive Order 11246, as amended by Executive Order 11375; Revised Order No. 4; the Equal Pay Act of 1963, as amended; the Rehabilitation Act of 1973, as amended; the Vietnam Era Veterans Readjustment Assistance Act of 1974; Titles VII and VIII of the Public Health Service Act; Title IX of the Education Amendments of 1972; the Americans With Disabilities Act (ADA) of 1990, and all applicable laws and ordinances of the State of New York, the City of Rochester, or other applicable regional governance.)

The success of the University of Rochester depends on an environment that fosters vigorous thought and intellectual creativity. It requires an atmosphere in which diverse ideas can be expressed and discussed. The University of Rochester seeks to provide a setting that respects the contributions of all the individuals composing its community, that encourages intellectual and personal development, and that promotes the free exchange of ideas.

To help establish and perpetuate an inclusive and open environment, all members of the University community are expected to support the University’s Equal Opportunity Statement.

The University of Rochester values diversity and is committed to equal opportunity for persons regardless of age, color, disability, ethnicity, gender identity or expression, genetic information, marital status, military/veteran status, national origin, race, religion/creed, sex, sexual orientation, or any other status protected by law. Further, the University complies with all applicable non-discrimination laws in the administration of its policies, admissions, employment, and access to and treatment in University programs and activities.

Questions on compliance with the Equal Opportunity Statement should be directed to the particular school or department and/or to the University’s Equal Opportunity Coordinator, Kathleen Sweetland, University of Rochester, P.O. Box 270039, Rochester, NY 14627-0039. Phone: (585) 275-9125—See HR Policy 100 The Equal Opportunity Coordinator also serves as the coordinator for grievances concerning claims of discrimination arising under Section 504 of the Rehabilitation Act of 1973, and Titles VI and IX of the Civil Rights Act of 1964.

Policy Against Discrimination and Harassment

Any behavior, including verbal or physical conduct, that constitutes unlawful discrimination against or harassment of any student, faculty, or staff member of the University community, based on protected class (e.g., race, gender, religion), is prohibited.

Retaliation is prohibited in any form against a person because he or she complained about conduct reasonably believed to be discrimination or harassment.

The University’s full policy on Discrimination and Harassment can be found in the Human Resources Policies and Procedures, # 106, available on the web at www.rochester.edu/working/hr/policies/ or in hard copy from the Office of Human Resources. The policy, which applies to all faculty, staff, and students, also describes the procedures available to address complaints of harassment and discrimination.

The Center for Student Conflict Management, (585) 275-4085, is responsible for handling campus conduct procedures dealing with the adjudication of incidents involving sexual assault and sexual harassment by students. (See www.rochester.edu/intercensor/assault/ for more information.)

What Is Sexual Assault?

Sexual assault refers to sexual contact without consent. Forms of sexual assault include rape, sexual abuse, attempted rape, and unwanted sexual touch. Sexual assault may, but need not, refer to sexual penetration, which includes vaginal intercourse, oral sex, or anal penetration. Sexual assault also includes conduct that involves any unwanted touching or fondling of the genitals or breasts of the victim. Date or acquaintance rape is sexual assault.

The University works to ensure that consistent supportive care of rape and sexual assault survivors is provided. Depending on the needs and the wishes of the survivor of the incident, a variety of on-campus supportive services can be put into place. If a survivor would prefer to work with off-campus agencies, assistance will be provided to make those contacts.

In all cases the safety and well-being of the survivor will determine what action will be taken. Survivors who have been physically injured can be referred to Strong Memorial Hospital...
Emergency Department or to the University Health Service depending on the severity of the injury. A University Security escort can be provided for those who need such assistance.

Whenever a survivor wishes to report an incident to University Security, an investigator will be notified. If an individual has not yet made a decision to file a report with University Security, but has concern about potential danger to themselves or to others, that person can be assisted in completing an anonymous proxy report that will allow University Security to be aware of some of the details of an incident without revealing the identity of the survivor. This practice allows University Security to protect the survivor and the rest of the campus community while allowing the survivor to determine whether and when she or he wishes to file a formal complaint.

If You Have Been Sexually Assaulted
The following resources can help you attend to your safety and medical and emotional needs.

- Rape Crisis Service at (585) 546-2777
- University Security at (585) 275-3333
- Rochester Police Department or the Monroe County Sheriff’s Office at 911
- University Counseling Center at (585) 275-3113
- or
- Go to the Emergency Room of any local hospital (University Security can provide a ride)

Please consider reporting the incident by contacting
- Rochester Police Department or the Monroe County Sheriff’s Office at 911
- The Center for Student Conflict Management at (585) 275-4085
- Rape Crisis Service at (585) 546-2777
- University Intercessor at (585) 275-9125
- University Security at (585) 275-3333
- University Security will create a report and notify the Center for Student Conflict Management

If the incident is reported to University Security, the Center for Student Conflict Management will

- contact you to schedule an appointment. During this appointment they will discuss
  - if a possible violation of the Standards of Student Conduct has occurred
  - whether additional safety measures may be taken, such as issuing a temporary Active Avoidance Order, locating alternative housing arrangements, or removing the alleged perpetrator from campus pending the outcome of the conduct process.
  - whether or not an administrative hearing is required.
  - ask you to schedule a time to speak with the University Intercessor to talk about your options and to insure that you are connected with the appropriate campus and community resources.
  - contact the alleged perpetrator to inform the student of the report and to determine whether a responsible option is appropriate.

Incident Involving a Non-Student
The University will help and support you if the perpetrator is a non-student. Please follow the first and second steps of this document in regards to taking care of your needs and reporting the incident.

If you have questions about reporting sexual assault or the conduct process, please contact: Center for Student Conflict Management at (585) 275-4085 or the University Intercessor at (585) 275-9125.

Misuse of Information Technology Resources
Information technology resources at the University of Rochester are designed to support the missions of the University, notably the creation and dissemination of new knowledge, by protecting the University’s resources, reputation, legal position, and ability to conduct its operations.

The right to use computing and telecommunications resources can be revoked if misused or abused. Activities and products must be consistent with the University’s academic ethics, including guidelines on computer security, prohibition of racial and sexual harassment, academic misconduct, nondiscrimination, confidentiality of records, appropriate use of computing facilities, as well as federal and state computer crimes statutes. Violations include, but are not limited to, commercial activities not approved by the University; use of information technology resources to harass or to create, store, or transmit libelous or obscene materials; copyright and licensing infractions; and infringement on rights of personal privacy.

All students should review and adhere to the following University policies:

- University’s Information Technology Policy
- University’s Acceptable Use Policy
- University’s Email Use Policy.

These policies can be found on the University IT website at www.rochester.edu/it/policy/.

File Sharing
Sharing copyrighted works without the copyright owner’s permission is illegal and a violation of University IT policy. Copyrighted works may include songs, films, television shows, video games and other software, and other original creative works. If the University receives a complaint against you from the Recording Industry Association of America (RIAA), the Motion Picture Association of America (MPAA), or other copyright holding associations, you will be notified by email. For each complaint filed against you, you will face escalating consequences:

- First complaint: You will receive a warning from University IT and an informal letter of warning from the Dean of Students Office.
Nonacademic Misconduct

1. Judicial officer receives a report of alleged misconduct
   
2. Judicial officer meets with persons involved

- Case dismissed
- Judicial officer will consult with appropriate college/school associate dean to confirm that matter should be treated as nonacademic
- Informal or administrative resolution

3. Judicial officer charges student with policy violation(s)

- Student accepts responsibility for policy violation(s)
- Student requests conduct hearing

4. Judicial officer works with student to determine appropriate response
   
   - Hearing
   - Conduct officers/teams submit recommendation to judicial officer

5. Decision of judicial officer communicated to student and victim, if any
   
   - Student/Victim appeals decision to appropriate dean/director
   - Decision accepted
   - Decision modified
   - Decision upheld
• Second complaint: You will have your RESNET and wireless network access suspended; there will be official disciplinary action from the Office of the Dean of Students including a $150 fine.

University action may also include, but may not be limited to:
• Termination of user privileges
• Disciplinary probation
• Community restitution
• Suspension or expulsion from the University of Rochester

To learn more about the implications of illegal file sharing and to learn about options for legal downloading, please visit the University IT website for Copyright and File Sharing at www.rochester.edu/it/security/yourself/file-sharing.html#Policy.

Misuse of University Letterhead
When an individual or group uses a University letterhead, or employs the phrase “University of Rochester” in a specially invented letterhead, there is the implication that the communication has the sanction of the University. Such letterheads are sometimes used inappropriately in letters or other documents to pursue a personal goal or for social or political purposes that are not the direct responsibility of the University. In these cases, such a letterhead should not be used, however worthy the cause and despite the fact that University members may be part or all of the membership of a group.

If there is any doubt about the appropriate use of a University letterhead, the provost or the president should be consulted.

Conduct Process for Nonacademic Misconduct
All complaints against graduate students should be forwarded to the appropriate associate dean of graduate studies within that student’s school who determines whether the complaint should be treated as an academic or a nonacademic matter. Academic matters will be referred to the appropriate associate dean, as explained on pages 36–38. Nonacademic matters will be referred to the judicial officer who will consult with the associate dean before going forward with any complaint against a graduate student that he or she receives from any source other than the associate dean.

The judicial officer will review the incident report or “complaint” and relevant documentation in order to determine whether or not there is sufficient cause to initiate disciplinary proceedings or pursue alternative means for resolution. Possible resolution options are as follows:
A. Dismiss the complaint.
B. Decide that the complaint can be processed through informal means of resolution, such as mediation. For more information about mediation, please contact the Center for Student Conflict Management at (585) 275-4085.
C. Defer the case pending dismissal. Deferment periods are generally not expected to last more than one semester.
D. Decide that the complaint contains grounds to reasonably believe that the University’s policies, rules, or regulations have been violated and charge the student, on behalf of the University, accordingly. If this action is taken, several procedures are possible, as explained below.

Order of Conduct Process
• Initial Meeting(s): When a student is reported to have engaged in behavior that may be detrimental to the University community, a conduct officer will reach out to the student and schedule an initial meeting. During this meeting the student will have the opportunity to read the report and share his or her perspective about what happened.

• Typically, during this meeting the conduct officer will work with the student to determine whether or not the student accepts responsibility for the possible policy violation. If the student accepts responsibility, the matter can be resolved at that time. If a student needs to participate in a formal conduct hearing, a pre-hearing conference meeting can be scheduled.

Students who participated in conduct hearings to determine whether or not a policy was violated are called “respondents.”

• Pre-Hearing Conference Meeting: During a pre-hearing conference meeting, the conduct officer meets with the respondent(s) and discusses the hearing process as outlined in the fundamental fairness section of this document on page 43.

• Hearing: The purpose of a formal hearing is to determine the truth about a respondent’s alleged misconduct. Through an objective and fair process guided by the fundamental fairness standards on page 43, a conduct officer or body (a) determines, based on the information gathered from all involved parties, whether or not a violation occurred and (b) recommends a response to the judicial officer if the respondent is found responsible.

• Post-Hearing Meeting: After the hearing the judicial officer or his or her designee will communicate with the respondent to discuss the outcome of the hearing and share information about how to submit an appeal if one is warranted.

Conduct Officers/Bodies
There are three different conduct bodies available for resolving alleged violations of the standards of the University community by graduate students. They are as follows:
• Residential Life Staff: Residential Life Area Coordinators, Assistant Directors, and Associate Directors resolve, whenever possible, alleged violations of policies by residents from their respective living areas. They are authorized to issue the full range of responses up to, but not including, suspension from the University and expulsion.

• Administrative Conduct Officer: An Administrative Conduct Officer—typically the judicial officer, the assistant director in the Center for Student Conflict Management, the director of Residential Life, an associate director of Residential Life, or a designee appointed by the judicial officer—may conduct disciplinary hearings without a board or council. Administrative conduct officers are authorized to issue the full range of University responses.
**Administrative Hearing Board:** The administrative hearing board is normally chaired by a designee of the judicial officer but may be chaired by the judicial officer him/herself, and consists of three faculty or staff members of the University community. This hearing board is authorized to issue the full range of University responses. Hearing board members are selected by the judicial officer based on the needs for fairness, objectivity, and balance in the resolution process. For alleged incidents of sexual assault, sexual harassment, racial harassment, and other illegal discrimination, hearing board members who have been specially trained to process such matters in a sensitive and appropriate manner are chosen.

Within a hearing, there are two decisions a team must reach. It must find whether there has been a violation of the University’s policies, rules, or procedures and if so, recommend an appropriate response. The purpose of the hearing team is to learn, to the best of its ability, the truth from all parties involved. The hearing team is not to assume the role of either prosecution or defense. The team treats both the accused and those providing testimony against the accused in the same manner.

**Fundamental Fairness in All Disciplinary Hearings**

A student will not be subject to official action for nonacademic misconduct unless

A. The student has had a conduct hearing OR
B. The student has waived the right to a hearing through a responsible option OR
C. The judicial officer has taken interim action (interim response pending a hearing) OR
D. Discretionary responsibility for resolving the matter has been retained by the president or a delegate.

The fundamental fairness points outlined below apply to all students who will participate in a hearing to determine whether they have violated the standards of our community. In many cases, the University is the only identifiable victim of an alleged offense, however, when the judicial officer identifies another student as a victim, they are also afforded the rights outlined below.

Fundamental fairness for disciplinary hearings at the University consists of the following standards:

1. All charges must be in writing and presented to the respondent and victim at the time of notification of the hearing.
2. Charges shall be reasonably specific as to the nature, time, and place of the alleged infraction.
3. The respondent and victim shall be informed of his or her rights in his or her preliminary meeting with the judicial officer.
4. The respondent and victim shall be afforded two (2) days to indicate a preference for which kind of hearing he or she wishes to have. This two-day limit shall also be the term during which offers for a Responsible Option, if offered, shall be valid. Final determination of hearing type shall be made by the judicial officer.
5. The respondent and victim shall be afforded at least seven days’ notice of the hearing in writing.
6. Hearings are normally scheduled within 14 business days after the hearing forum has been selected; however, the judicial officer may extend time lines to accommodate the academic calendar or other extenuating circumstances.
7. The respondent and victim may indicate a preference for an open or closed hearing. (open hearings can be attended by members of the University community, and information about the incident and hearing can be made available to members of the University community). In the absence of an indicated preference, hearings are closed. Final determination of whether a hearing will be an open or closed hearing shall be made by the judicial officer.
8. The respondent and victim shall have the right to be accompanied by an advisor who may confer with and assist the accused but may not speak for him or her as an advocate. The advisor must be a member of the University community who is not an attorney. Names of recommended advisors who are well informed about disciplinary procedures are available from the Center for Student Conflict Management. Respondents and victims are strongly encouraged to choose an advisor knowledgeable in the conduct process. In cases involving allegations of sexual assault or harassment, advisors may not be undergraduate students.
9. Hearings are recorded. A recording of the hearing will be available in the event of an appeal, but remains the property of the University.
10. The respondent and victim shall have the opportunity to answer accusations and to submit the testimony of material witnesses on his or her own behalf. Witness statements, security reports, residential life incident reports, and depositions—scheduled with the judicial officer and respondent—shall be acceptable as documentation submitted to a board. All other documentation is subject to review by the judicial officer prior to the time of the hearing.
11. All evidence and testimony, including the relevant security reports, the text of statements made by the respondent and victim prior to the hearing and used at the hearing, and any physical evidence shall be presented in the presence of the respondent and the victim; however, legal rules of evidence shall not apply.
12. Relevant reports, documents, and other evidence may be reviewed by the respondent and victim in the Center for Student Conflict Management prior to the hearing. Copies of any such material may not, however, leave the office.
13. The respondent and victim shall have the opportunity to indirectly question (through the hearing teams/officers) all witnesses present during the hearing. This does not necessarily include the right to confront witnesses in person.
14. The respondent and victim shall be given an opportunity to make statements which will become part of the case record to be reviewed by the judicial officer and by any dean or director considering an appeal.
15. The respondent and victim will participate in separate hearing rooms (connected electronically) unless otherwise requested in order to allow full participation of the parties.

16. Respondents and victims should be aware of the fact that they may be required to refrain from speaking publicly about the outcome of judicial cases due to laws and University policies. In the event that such is necessary, the respondent and victim will be informed by the judicial officer.

17. The respondent, victim, and all other participants are expected to cooperate during the hearing and be truthful in their testimony and responses to questions. A respondent or victim may choose to refrain from providing testimony or answering questions; however, he or she may not then provide a statement on his or her behalf. Depending on all the information presented, a respondent who refuses to give testimony or answer questions may nonetheless be found responsible by the hearing officer of body.

18. The conduct board/officers shall determine by a majority vote whether it is more likely than not (i.e., by a preponderance of the evidence) that the respondent violated a University policy, rule, or regulation.

19. The findings and recommendations of the conduct board/officers will be forwarded to the judicial officer. In the event the judicial officer does not accept the findings or recommendation of the conduct board/officers, he or she may request further consultation and review by the conduct board/officers or may make a different finding or recommendation if warranted by the evidence presented at the hearing. The judicial officer will notify the respondent and victim of the outcome, unless prohibited by law.

20. The respondent and victim have the right to appeal a final decision in a nonacademic case to the appropriate dean/director and in an academic case to the provost.

21. The judicial officer has discretion to modify, expand, or clarify these standards and any other aspect of the disciplinary process, depending on the circumstances.

Responses to Misconduct
Creating a space that allows members of the University community to live and work in a safe and respectable environment is an important component of the conduct process. A major goal of the conduct process in particular and the University in general is to teach why something is wrong as well as to prevent its repetition. This goal is often difficult to carry out, but an effort is made to create a response that will best educate the student or group involved.

Common Responses
This list is by no means inclusive of all options open to conduct officers and boards in creating appropriate responses for individual offenses.

- **Disciplinary Warning**, including an official letter of reprimand to the student stating that his or her behavior is in violation of University policy and may not recur.

- **Community Restitution**, which may require individuals or groups to write a letter of apology, participate in a designated service project, or give an identified community (on or off campus) a number of service hours to be completed within a specified time period. When appropriate, the individual or group may be required to devise its own community restitution plan to be approved by the judicial officer or his or her designee.

- **Counseling Intervention**, which may be recommended, and in some cases required, when behavior indicates that the counseling may be beneficial to the student. Specific circumstances will determine an appropriate mental health service referral, which may include drug, alcohol, and other educational workshops. Such mandated interventions may be at the student’s cost.

- **Financial Restitution**, which may require individuals or groups to restore or replace within a specified time, property which has been damaged, defaced, lost, or stolen.

- **Revocation or Restriction of Privileges**, for the use of designated University facilities or programs.

- **Disciplinary Probation**, which normally consists of an official notice that further violation of University policy will result in serious consideration being given that the individual or group not be permitted to continue as a student or group at the University of Rochester. This is a serious warning which serves as a check on the student’s or group’s future behavior. Once a student or group is on probation, any further disciplinary action will be more severe. Probation is given for a period of time and can limit the activities or privileges of a student or group. For example, students on probation are not able to join a fraternity or sorority nor are they permitted to study abroad.

  Student groups that are placed on probation may be placed in one of two probationary categories:

  - **Social Probation**: A group on social probation is not permitted to hold functions/gatherings where alcohol is present.

  - **Formal Disciplinary Probation**: A group on formal disciplinary probation is not permitted to hold any functions or gatherings, including those gatherings that only involve its members.

- **Suspension from University Housing**, which involves revocation of the privilege of living in University housing for a certain period of time. Students or groups who have their housing contracts or leases terminated for disciplinary reasons are not entitled to a reimbursement.

- **Suspension**, which generally involves the revocation of the privilege of attending the University and using its facilities for at least one full year. Upon the conclusion of the term of the suspension, students need to request readmission to the University and may be required to meet additional conditions for re-entry.

- **Expulsion**, which means the student is permanently separated from the University. He or she may not apply for readmission to any program.

Other common responses may include alteration of housing selection privileges; research assignments; project, program, and presentation requirements; revocation of other University
privileges (e.g., access to computer systems, dining venues, sports and recreation facilities); mandated follow-up meetings with University officials; mandated supervised study hours.

Once a response is issued, it is the responsibility of the student to ensure that the response is completed in a timely fashion. Failure to complete an assigned response will result in an additional charge and will be handled administratively by the judicial officer or his or her designee. Students failing to complete conduct responses normally have their student accounts placed on hold (making them unable to register for classes or receive transcripts) until such response is completed.

Appeals

Grounds for Appeal
An appeal is intended to provide an opportunity to consider any previously overlooked, exceptional, or unfair circumstances pertinent to the case. It is not intended to be a rehearing of the events presented at the original hearing. The only grounds on which an appeal can be made are
1. the response was not appropriate
2. new information exists that was not available at the time of the hearing and this information is sufficient to alter the decision or
3. an error occurred during the process that is substantive enough to alter the decision.

Process of Appeal
An appeal must be made in writing to the appropriate dean/director (for nonacademic cases) or to the provost (for academic cases) within seven days of the date of the letter officially stating the original decision.

The name and contact information for the appropriate dean/director to whom the appeal should be submitted will be included in the decision letter. The letter must state the grounds on which an appeal is made and what the student believes supports an appeal on those grounds. The dean/director or provost may review material from the original hearing before considering an appeal. The dean/director or provost may consult with anyone he or she feels is pertinent to, or would be helpful in determining, the appeal.

Effect of Appeal
The student appealing will receive a written decision from the dean/director or provost. On appeals, the dean/director or provost may modify the decision, or the case may be referred back to a board for a new hearing. At the discretion of the dean/director or provost and upon the recommendation of the judicial officer, where appropriate, all or some of the responses may be suspended pending the final decision.

Conduct Records
Student records, including files from disciplinary cases currently suspended or expelled from the University for conduct reasons. University staff who have knowledge of action taken against a student for misconduct may on occasion be asked to respond to inquiries regarding the student’s involvement in disciplinary action. In accordance with the confidentiality of such records, the University officer may only reveal such information with the authorization of the student, except when required by law or when the University officer perceives a significant risk to the safety or well-being of that student or others. Conduct files are normally destroyed seven years after the student's separation from the University. However, certain University officials may indefinitely retain records in other appropriate circumstances.
Administrative Officers

Peter Lennie, PhD  
Provost and Robert L. and Mary L. Sproull Dean of the Faculty of Arts, Sciences & Engineering

Richard Feldman, PhD  
Dean of the College

Wendi Heinzelman, PhD  
Dean of Graduate Studies

David Williams, PhD  
Dean for Research

Suzanne J. O’Brien, BA  
Associate Dean of the College

Beth Olivares, PhD  
Associate Dean for Diversity Initiatives and Executive Director of the McNair Program

Nancy Speck, BA  
Assistant Dean for Institutional Research and University Registrar

Paul Spaulding, BS  
Senior Operations Officer

Jessica Foster, MBA  
Senior Administrative Officer

Roger Smith, MBA  
Senior Financial Officer

Devarajulu Ravichandran, MBA  
Senior Information Technology Officer

Crystal Cusimano, MS  
Faculty Affairs Officer

Committee on Graduate Studies

The Committee on Graduate Studies shall consist of the following members: the delegate of the Dean of the Faculty who shall be chair; the Dean of the Faculty and the University Dean of Graduate Studies, both ex-officio; the Director of Graduate Studies for each program that offers a PhD or master’s degree; and four graduate students (one from each of the four major disciplinary domains: the humanities, the social sciences, the natural sciences, and engineering). Election of the graduate student members shall be by the vote of graduate students.

A faculty representative shall serve for as long as she or he is the program’s Director of Graduate Studies. When a program selects a new Director of Graduate Studies, this member will join the Committee on Graduate Studies. The terms of the student representatives shall be one year. To obtain a list of the current members of the Committee on Graduate Studies, please contact the Graduate Studies Office.

Special Requirements for Arts, Sciences & Engineering

Admission Regulations

Applicants for admission to graduate work must demonstrate to the dean of graduate studies as well as the department of their major interest that their training and ability are such as to ensure reasonable chances of success in work towards advanced degrees. All applicants for admission must present evidence that, exclusive of introductory courses, they have completed no less than 18 credit hours of college work of high standing in their principal subject of study, or a satisfactory equivalent. Students with satisfactory undergraduate records that do not include 18 hours of credit in the field of their choice may be admitted and required to complete prerequisites prescribed by the department. Preparation in related subjects must be satisfactory, and applicants may be required to have knowledge of the skills essential to their fields of study. Undergraduate programs should provide evidence that students have taken relevant introductory work in the humanities, social sciences, sciences, or engineering.

To be assured credit for graduate work, admission to graduate studies should precede any work done at the University of Rochester that is to be applied toward the master’s or PhD degree.
Degree Requirements
University regulations that apply to the Master of Arts, Master of Science, and Doctor of Philosophy degrees are enumerated earlier in this bulletin under the heading Graduate Degrees. Additional requirements for Arts, Sciences & Engineering graduate students are listed here and in the individual departments’ sections.

PhD Degree Requirements
The degree Doctor of Philosophy requires the equivalent of 90 hours of work beyond the bachelor’s degree and at least one academic year of full-time study in residence. The program of study for the degree Doctor of Philosophy must be submitted for the approval of the dean of graduate studies within two years of matriculation.

All PhD students in Arts, Sciences & Engineering must take the qualifying examination either before starting their seventh semester of study or before the fourth calendar year, whichever is longer. In exceptional circumstances, and with the prior approval of the dean of graduate studies, these limits may be extended. A department may require the student to take the qualifying examination before the stated time limits. Six months must elapse between the qualifying examination and the final oral examination (thesis defense).

By action of the Committee on Graduate Studies, the following departmental PhD qualifying examination committees are not required to include a member from outside the department: Biology, Brain and Cognitive Sciences, Chemistry, Clinical and Social Sciences in Psychology, Earth and Environmental Sciences, Economics, Mathematics, Philosophy, Physics and Astronomy, and Political Science.

Master of Arts and Master of Science Degree Requirements
The degrees Master of Arts and Master of Science under Plan A are awarded for successful completion of at least 30 hours of graduate credit. Of these 30 credit hours, at least 6 and normally no more than 12 hours must be in research/reading courses, and at least 18 hours must be in formal coursework. A minimum of 12 of the 18 credit hours of formal coursework must be at the 400 level. A limit of 12 credit hours at the 200–300 level can be approved on the Program of Study. The student must also successfully defend a written thesis.

The degrees Master of Arts and Master of Science under Plan B are awarded for successful completion of at least 30 hours of graduate credit, and satisfactory performance on an oral, written, or essay comprehensive examination in the student’s field of specialization. The qualifying examination for the PhD degree may be substituted. Of the required 30 credit hours, at least 18 of these hours must be in the student’s principal department or program, and at least 18 hours in the approved master’s program must be in formal courses numbered 400 or higher. A limit of 12 credit hours at the 200–300 level can be approved on the Program of Study. If the department requires a master’s essay, this course is in addition to the minimum requirement of 18 hours of courses numbered 400 or higher, and it may carry up to 4 hours of credit. Total credit for research, reading, and the master’s essay cannot exceed 6 hours.

The program of study for the degree Master of Arts or the degree Master of Science must be submitted for the approval of the dean of graduate studies within two semesters of matriculation. Part-time master’s candidates must file a proposed program of study upon the completion of 12 hours of graduate credit.

Master of Arts and Master of Science degrees in interdepartmental studies within fields of study in Arts, Sciences & Engineering that have viable master’s degree-granting programs allow students to combine work in fields of study that have been considered separate or merely allied to develop degree programs that meet new and specialized interests. The procedures for planning and approval of an interdepartmental master’s degree program are handled through the Arts, Sciences & Engineering Graduate Studies Office (GSO) in Lattimore Hall. Once students have a general idea of their areas of interest, they need to review the course offerings in the degree-granting departments with which they will develop the interdepartmental degree. Initial inquiries should be directed to the Graduate Studies Office in 218 Lattimore Hall. Students must apply to and be accepted into the degree-granting departments with which they will develop the interdepartmental degree.

Grading
A student who receives the grade of C or E in one or more courses will be considered to have an unsatisfactory record and will be automatically placed on Arts, Sciences & Engineering academic probation. A student on academic probation may not be awarded a graduate degree. To be removed from academic probation, the student must complete 12 semester hours of graduate credit with no grade lower than B–. If the student receives any grade lower than B–, the student is subject to removal from the program. In special cases, this may be reviewed by the dean of graduate studies.

Students receiving C grades in courses in excess of 20 percent of their complete programs are considered to have unsatisfactory records; they cannot graduate until their programs of study have been adjusted to eliminate the excess. In special cases, this may be reviewed by the dean of graduate studies.

The grade of I (Incomplete) is an option providing a student with additional time to complete unfinished work. It may only be used in conjunction with a Memorandum of Understanding between the student and the instructor describing precisely what additional work must be completed by the student to enable the instructor to assign a final course grade, and when this additional work must be completed. With the exception of extraordinary circumstances, as determined by the dean of graduate studies, this additional work must be completed no later than one calendar year (two semesters) after the end of the semester in which the original course was taken. If the work is completed within one calendar year, the official transcript will show only the final grade the instructor assigns. If the work is completed after one calendar year, the official transcript will show an I and the final grade.
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Professor Emeritus of Psychology

Jianhui Zhong, PhD (Brown)  
Professor of Imaging Sciences, of Biomedical Engineering, and of Physics

Miron Zuckerman, PhD (Harvard)  
Professor of Psychology

Matthew Bailey, PhD (Yale)  
Associate Professor of Music in the College and of Musicology in the Eastman School of Music

Paulo Barelli, PhD (Columbia)  
Associate Professor of Economics

Daniel Beaumont, PhD (Princeton)  
Associate Professor of Arabic Language and Literature

Loisa Bennett, PhD (Denver)  
Associate Professor of Psychology and of Brain and Cognitive Sciences

Cheeptip Benyajati, PhD (Princeton)  
Associate Professor of Biology

Joanne Bernardi, PhD (Columbia)  
Associate Professor of Japanese

Xin Bi, PhD (Johns Hopkins)  
Associate Professor of Biology

Curt Cadorette, PhD (University of St. Michael’s College)  
Associate Professor of Religion and John Henry Newman Associate Professor of Roman Catholic Studies

Yongsung Chang, PhD (Rochester)  
Associate Professor of Economics

Kevin Clarke, PhD (Michigan)  
Associate Professor of Political Science

Elizabeth Cohen, MFA (Rhode Island School of Design)  
Associate Professor of Art

Peter Como, PhD (Delaware)  
Associate Professor of Psychology, of Psychiatry, and of Brain and Cognitive Sciences

Richard Dees, PhD (Michigan)  
Associate Professor of Philosophy and of Psychology, of Neurology, of Pediatrics, and of Medical Humanities

Ayala Emnett, PhD (Rochester)  
Associate Professor of Anthropology

Mark Fey, PhD (California Institute of Technology)  
Associate Professor of Political Science

William FitzPatrick, PhD (California, Los Angeles)  
Associate Professor of Philosophy

Signithia Fordham, PhD (American University)  
Associate Professor of Anthropology

Edward Freedman, PhD (Pennsylvania)  
Associate Professor of Neurobiology and of Psychology, of Biomedical Engineering, and Assistant Professor in the Center for Visual Science

Alison Frontier, PhD (Columbia)  
Associate Professor of Chemistry

James Fry, PhD (Michigan)  
Associate Professor of Biology

Gerald Gamm, PhD (Harvard)  
Associate Professor of Political Science and of History
Lin Gan, PhD (Texas, Houston)  
Associate Professor of Neurobiology and Anatomy, of Ophthalmology and in the Center for Visual Science

Carmala N. Garzione, PhD (Arizona)  
Associate Professor of Geology

Dan-Andrei Geba, PhD (Princeton)  
Associate Professor of Mathematics

Alfred Geier, PhD (Johns Hopkins)  
Associate Professor of Classics

John Givens, PhD (Washington)  
Associate Professor of Russian

Richard Glor, PhD (Washington University)  
Associate Professor of Biology

Hein Goemans, PhD (Chicago)  
Associate Professor of Political Science

George Grella, PhD (Kansas)  
Associate Professor of English and of Film Studies

Jennifer Grotz, PhD (Houston)  
Associate Professor of English

Rachel Haidu, PhD (Columbia)  
Associate Professor of Art History and of Visual and Cultural Studies

Gretchen Helmké, PhD (Chicago)  
Associate Professor of Political Science

Jay Hong, PhD (Pennsylvania)  
Associate Professor of Economics

Larry E. Hudson, PhD (Keele)  
Associate Professor of History

Michael Jarvis, PhD (William and Mary)  
Associate Professor of History

Rulang Jiang, PhD (Wesleyan)  
Associate Professor of Biomedical Genetics in the Center for Oral Biology and of Biology

Naomi Jochnowitz, PhD (Harvard)  
Associate Professor of Mathematics

Andrew Jordan, PhD (California, Santa Barbara)  
Associate Professor of Physics

Barbara Jordan, MA (Boston)  
Associate Professor of English

Anastassios Kalandrakis, PhD (California, Los Angeles)  
Associate Professor of Political Science

Rosemary Kegl, PhD (Cornell)  
Associate Professor of English

Cilas Kemedjio, PhD (Ohio State)  
Associate Professor of French

John Kessler, PhD (California, Irvine)  
Associate Professor of Earth and Environmental Sciences

David Lambert, PhD (Arizona)  
Associate Professor of Biology

Matthew Lenoe, PhD (Chicago)  
Associate Professor of History

Stephanie Li, PhD (Cornell)  
Associate Professor of English

David McCamant, PhD (California, Berkeley)  
Associate Professor of Chemistry

Joyce McDonough, PhD (Massachusetts)  
Associate Professor of Linguistics and of Brain and Cognitive Sciences

Ernestine McHugh, PhD (California, San Diego)  
Associate Professor of Anthropology and Religion in the Eastman School of Music and Associate Professor of Anthropology

Bonnie Meguid, PhD (Harvard)  
Associate Professor of Political Science

Jonathan W. Mink, MD, PhD (Washington University)  
Associate Professor of Neurology, of Neurobiology and Anatomy, of Pediatrics, and of Brain and Cognitive Sciences

Alyssa Ney, PhD (Brown)  
Associate Professor of Philosophy

Thomas O’Connor, PhD (Virginia)  
Associate Professor of Psychiatry and of Psychology

William E. O’Neill, PhD (SUNY, Stony Brook)  
Associate Professor of Neurobiology and Anatomy and of Brain and Cognitive Sciences

Jonathan Pakianathan, PhD (Princeton)  
Associate Professor of Mathematics

Donna R. Palumbo, PhD (New School University)  
Associate Professor of Neurology, of Pediatrics and of Psychology

Ronni Pavan, PhD (Chicago)  
Associate Professor of Economics

Jean Pedersen, PhD (Chicago)  
Associate Professor of History in the Eastman School of Music and of History

Michael Peress, PhD (Carnegie Mellon)  
Associate Professor of Political Science

Ryan Prendergast, PhD (Emory)  
Associate Professor of Spanish

Daven Presgraves, PhD (Rochester)  
Associate Professor of Biology

David Primo, PhD (Stanford)  
Associate Professor of Political Science

Raúl Rodríguez-Hernández, PhD (Cornell)  
Associate Professor of Spanish

Ronald Rogge, PhD (California, Los Angeles)  
Associate Professor of Psychology

Lizabeth Romanski, PhD (Cornell)  
Associate Professor of Neurobiology and Anatomy and in the Center for Visual Science

Deborah Rossen-Knill, PhD (Minnesota)  
Associate Professor in the College Writing Program

Jeffrey Runner, PhD (Massachusetts, Amherst)  
Associate Professor of Linguistics and of Brain and Cognitive Sciences

Joan Saab, PhD (NYU)  
Associate Professor of Art History and of Visual and Cultural Studies

Sema Salur, PhD (Michigan State)  
Associate Professor of Mathematics

Grace Seiberling, PhD (Yale)  
Associate Professor of Art History

Elaine Sia, PhD (Columbia)  
Associate Professor of Biology

Curtis Signorino, PhD (Harvard)  
Associate Professor of Political Science

Donatella Stocchi-Perucchio, PhD (Cornell)  
Associate Professor of Italian

Ezra Tawil, PhD (Brown)  
Associate Professor of English

Allen Topolski, MFA (Pennsylvania State)  
Associate Professor of Art
Sheree Toth, PhD (Case Western Reserve)
  Associate Professor of Psychology
Jeffrey Tucker, PhD (Princeton)
  Associate Professor of English
Thomas Tucker, PhD (California, Berkeley)
  Associate Professor of Mathematics
Michael Welte, PhD (Chicago)
  Associate Professor of Biology
Peter Wyman, PhD (Rochester)
  Associate Professor of Psychiatry and of Psychology
Geun-Young Yoon, PhD (Osaka University)
  Associate Professor of Ophthalmology, of Biomedical Engineering, of Optics, and in the Center of Visual Science

Avidit Acharya, PhD (Yale)
  Assistant Professor of Political Science
Antonio Badolato, PhD (California, Santa Barbara)
  Assistant Professor of Physics and Astronomy
Yan Bai, PhD (Minnesota)
  Assistant Professor of Economics
Corbett Bazler, PhD (Columbia)
  Assistant Professor of Music
Matthew Blackwell, PhD (Harvard)
  Assistant Professor of Political Science
John Boersma, PhD (Texas–Austin)
  Assistant Professor of Physics
Joel Burges, PhD (Stanford)
  Assistant Professor of English
Mandi Burnette, PhD (Virginia)
  Assistant Professor of Psychology
Carolina Caetano, PhD (California, Berkeley)
  Assistant Professor of Economics
Gregorio Caetano, PhD (California, Berkeley)
  Assistant Professor of Economics
Jessica Cantlon, PhD (Duke)
  James P. Wilmot Distinguished Professor in Arts, Sciences and Engineering and Assistant Professor of Brain and Cognitive Sciences
Bin Chen, PhD (Cornell)
  Assistant Professor of Economics
Millicent Chung, MD (Yale)
  Assistant Professor of Ophthalmology and in the Center for Visual Science
Elizabeth Colantoni, PhD (Michigan)
  Assistant Professor of Classics
Jennifer Creech, PhD (Minnesota)
  Assistant Professor of German
Robert Doran, PhD (Stanford)
  James P. Wilmot Distinguished Assistant Professor in Arts, Sciences and Engineering and Assistant Professor of French
Kristin Doughty, PhD (Pennsylvania)
  Assistant Professor of Anthropology
Joshua Dubler, PhD (Princeton)
  Assistant Professor of Religion and Classics
Rudi Fasan, PhD (Zurich)
  Assistant Professor of Chemistry
Aran Garcia-Bellido, PhD (Royal Holloway University, London)
  Assistant Professor of Physics
Daniel Garriga, PhD (Arizona State)
  Assistant Professor of Biology Sina Ghaemmaghami, PhD (Duke)
  Assistant Professor of Biology
Margarita Guillory, PhD (Rice)
  Assistant Professor of Religion and Classics
Douglas Haessig, PhD (California, Irvine)
  Assistant Professor of Mathematics
Benjamin Hayden, PhD (California, Berkeley)
  Assistant Professor of Brain and Cognitive Sciences
Dahpon Ho, PhD (California, San Diego)
  Assistant Professor of History
Krystal Huxlin, PhD (Sydney)
  Research Assistant Professor of Ophthalmology and in the Center for Visual Science
June Hwang, PhD (California, Berkeley)
  Assistant Professor of German
T. Florian Jaeger, PhD (Stanford)
  Assistant Professor of Brain and Cognitive Sciences, of Computer Science, and in the Center for Visual Science
Jeremy Jamieson, PhD (Northeastern)
  Assistant Professor of Psychology
Stuart Jordan, PhD (Princeton)
  Assistant Professor of Political Science
Eleana Kim, PhD (New York University)
  James P. Wilmot Distinguished Assistant Professor in Arts, Sciences and Engineering and Assistant Professor of Anthropology
Joshua Kinsler, PhD (Duke)
  Assistant Professor of Economics
Asen Kochov, PhD (University of Rochester)
  Assistant Professor of Economics
Jennifer Kyker, PhD (Pennsylvania)
  Assistant Professor of Music
Bethany A. Lacina, PhD (Stanford)
  Assistant Professor of Political Science
Evelyn Leblanc-Roberge, PhD (NYSCC)
  Assistant Professor of Art and Art History
Richard Libby, PhD (Boston College)
  Assistant Professor of Ophthalmology and in the Center for Visual Science
Dan Lu, PhD (Chicago)
  Assistant Professor of Economics
Bradford Mahon, PhD (Harvard)
  Assistant Professor of Brain and Cognitive Sciences, of Neurosurgery, and in the Center for Visual Science
Anna Majewska, PhD (Columbia)
  Assistant Professor of Neurobiology and Anatomy and in the Center for Visual Science
Eric Mamajek, PhD (Arizona)
  Assistant Professor of Physics and Astronomy
Katherine Mannheimer, PhD (Yale)
  Assistant Professor of English
*Albert Memmott, PhD (Minnesota)
  Assistant Professor of English
Ryan Michaels, PhD (Michigan)
  Assistant Professor of Economics

* Part-time
Jason Middleton, PhD (Duke)
Assistant Professor of English

Michael Neidig, PhD (Stanford)
Assistant Professor of Chemistry

Wendy J. Nilsen, PhD (Purdue)
Assistant Professor of Psychiatry and of Psychology

Bradley Nilsson, PhD (Wisconsin-Madison)
Assistant Professor of Chemistry

John Osburg, PhD (Chicago)
Assistant Professor of Anthropology

Romans Pancs, PhD (Stanford)
Assistant Professor of Economics

Cary Peppermint, MFA (Syracuse)
Assistant Professor of Art and Art History

Alison Peterman, PhD (Northwestern)
Assistant Professor of Philosophy

Vasili Petrenko, PhD (California, San Diego)
Assistant Professor of Earth and Environmental Sciences

Douglas Portman, PhD (Pennsylvania)
Assistant Professor of Biomedical Genetics and of Biology

Supritha Rajan, PhD (North Carolina)
Assistant Professor of English

Daniel Reichman, PhD (Cornell)
Assistant Professor of Anthropology

Chuang Ren, PhD (Wisconsin-Madison)
Assistant Professor of Mechanical Engineering and of Physics and Scientist in the Laboratory for Laser Energetics

Nora Rubel, PhD (North Carolina)
Assistant Professor of Religion

William Schaefer, PhD (Chicago)
Assistant Professor of Modern Languages and Cultures

Keith Schneider, PhD (Rochester)
Assistant Professor (Research) in the Center for Brain Imaging, in Biomedical Engineering, and in the Center for Visual Science

Stephen Schottenfeld, MFA (Iowa)
Assistant Professor of English

Andrei Seluanov, PhD (Weizmann Institute of Science)
Assistant Professor (Research) of Biology

Maya Sen, PhD (Harvard)
Assistant Professor of Political Science

Brett Sherman, PhD (Princeton)
Assistant Professor of Philosophy

Melissa Sturge-Apple, PhD (Notre Dame)
Assistant Professor of Psychology

Duje Tadin, PhD (Vanderbilt)
Assistant Professor of Brain and Cognitive Sciences and in the Center for Visual Science

Daniel Weix, PhD (California, Berkeley)
Assistant Professor of Chemistry

Bradley Weslake, PhD (Sydney)
Assistant Professor of Philosophy

Lisa Willis, PhD (Rochester)
Assistant Professor of Psychiatry and of Psychology

Nese Yildiz, PhD (Stanford)
Assistant Professor of Economics

Elya Zhang, PhD (California, San Diego)
Assistant Professor of History

Jan Toke, PhD (Warsaw Univ., Poland)
Senior Scientist in Chemistry
Professors Calver (Chair), Eickbush, Goldfarb, Gorbunova, Jacek, Olmsted, Orr, Platt, Werren
Associate Professors Benyajati, Bi, Fry, Glor, Presgraves, Sia, Wels
Assistant Professors Garrigan, Ghaemmamahi, Jasper, Lambert, Ramsey, Seluanov
Joint Appointments: Assistant Professor Ermolenko; Associate Professor Gill; Assistant Professor Portman
Professors Emeriti Bannister, Gorovsky, Hall, Hattman, Hinkle, Hoch, Kaye, Muchmore

The Department of Biology offers programs of research and study leading to the MS and PhD degrees in a broad spectrum of disciplines, with special emphasis on the areas of molecular-cellular-developmental biology, genetics, ecology, and evolutionary biology.

PhD Curricula

The aim of these programs is preparation of independent professional biologists, qualified for teaching and scholarly research at the college and graduate levels or for positions of leadership in industrial research. Award of the doctorate recognizes the following achievements: breadth of general knowledge in biology, research expertise in one or more areas of contemporary specialization, mastery of related disciplines (e.g., mathematics, chemistry, physics, or computer science) as appropriate to the area of specialization, skill in analysis and in written and oral communication of scientific information, and at least one major contribution toward the solution of a significant biological problem, presented in the form of a scholarly dissertation.

Formal course requirements are kept to a minimum in order to give students and their advisors the opportunity to design individual programs of study appropriate to the student’s interest and preparation, and to provide students with the opportunity to take advantage of educational resources throughout the University. Many such opportunities exist in other departments and institutes, especially those in the adjacent medical school.

Students entering with the baccalaureate in science and adequate preparation in biology normally complete the doctorate in five to six years. The first year of graduate work includes both formal coursework and research experience. Courses are selected in consultation with faculty advisors to fill gaps in undergraduate preparation (if any), to assist the student in identifying an area of special interest for research, and to achieve an appropriate balance between breadth of preparation and intensive study in a chosen subdiscipline. Research in the first year is carried out in a rotation through three different laboratories. Students work on short projects that introduce them to the investigations in each laboratory and provide a basic repertoire of research skills. Students begin their PhD research in the laboratory of a chosen faculty member at the end of the first year.

Admission to candidacy for the PhD degree requires successful completion of an oral examination, which includes defense of a thesis proposal. This exam is normally completed by the end of the second year. Periodic meetings with a thesis advisory committee are required to aid the student in critically evaluating results, assigning priorities, and considering alternative experimental strategies.

The PhD degree is awarded following the successful defense of a written dissertation before a committee of examiners.

Teaching Requirement

Graduate students make a valuable contribution to the instructional programs of the department as teaching assistants in recitation sections or in laboratory courses. All candidates for the PhD degree are required to assist in the teaching of a minimum of two courses. Additional teaching effort is required of students supported as teaching assistants.

MS Curricula

The purpose of these programs is to provide advanced training in biology for those whose goals do not call for establishment of independent research laboratories or for training of postgraduate students. Applicants for MS candidacy include those in school science teaching, and those preparing for nonacademic careers requiring strong preparation in biology, including research positions in the health professions or industry. The MS recognizes competence in selected subdisciplines demonstrated by successful completion of a coherent set of courses, and, either defense of a thesis based upon independent research (Plan A) or adequate performance in a special comprehensive examination (Plan B). Students electing Plan B must offer the equivalent of four credit hours in laboratory work, completed in the form of graduate laboratory courses, as independent investigation, or by some combination of the two. The time required to complete either plan is one to two years.

Prerequisites

Most applicants for graduate work in biology have completed BS or BA curricula with majors either in biological sciences or in a related science including at least five courses in biology. Minimum preparation in physics, calculus, and organic chemistry is normally one year of each. Deficiencies in particular undergraduate courses do not necessarily weaken an application if preparation is otherwise strong, and aptitude is clearly demonstrated. Any such deficiencies should be made up early in the graduate program by attendance at appropriate graduate courses or, if necessary, at undergraduate courses which do not carry graduate credit.

402. Molecular Biology

Prerequisites: courses in genetics and biochemistry are strongly recommended.

This course deals with the molecular mechanisms of DNA replication, DNA repair, transcription, translation, and control of gene expression. Discussions include cell cycle regulation, programmed cell death, molecular basis of cancer, and modern molecular biology techniques. Emphasis is given to mammalian systems and molecular mechanisms of human diseases.
405. Evolution
Prerequisite: introductory course in genetics.

Introduction to evolutionary biology. Topics include history of evolutionary thought, population and quantitative genetics, origin and history of life, speciation, and human evolution.

420. Advanced Cell Biology
Prerequisites: introductory courses in genetics, biochemistry, and cell biology are recommended.

An advanced course focusing on a mechanistic understanding of cellular organization and function. This course relies heavily on the primary research literature and emphasizes the design and interpretation of experiments, drawn from biochemistry, microscopy and genetics. Topics include the cytoskeleton, membrane traffic, cell-cell signaling, and the cell cycle. Introduction to professional skills such as dissecting articles, giving presentations, and writing proposals.

422. Biology of Aging
Prerequisite: introductory course in genetics or molecular biology is required.

This course focuses on molecular mechanisms of aging. Discussions cover popular theories of aging, model organisms used in aging research, evolution of aging, relation between aging and cancer, human progeroid syndromes, and interventions to slow aging.

426. Developmental Biology
Prerequisite: none.

This course deals with the cellular and molecular aspects of animal development, with emphasis on processes and underlying mechanisms. Topics include embryonic cleavage, gastrulation, early development of model vertebrates and invertebrates, patterning of cell fates along embryonic axes of Drosophila and vertebrates, organogenesis, and stem cells.

443. Eukaryotic Gene Regulation
Prerequisites: introductory courses in genetics, biochemistry, and molecular biology are strongly recommended.

This course systematically examines the organization of the eukaryotic genome and its role in the regulation of gene expression. Topics discussed include structure of chromosomes, mechanisms of gene activation and transcription, epigenetic gene regulation, regulatory networks, and functional genomics. Lectures and readings draw heavily on current and classic primary literature.

453. Computational Biology
Prerequisite: none.

An introduction to the history, theory, and practice of using computers to conduct biological research. Topics include the fundamentals of Linux-based computing and perl programming, accessing and storing biological data, alignment of molecular sequences, and computer-based analysis of data.

460. Animal Behavior
Prerequisite: introductory courses in biology and genetics.

Examines animal behavior from an ecological and evolutionary perspective. Topics include social organization, mating systems, foraging, animal learning, and aggression. Students also learn quantitative techniques in behavioral biology.

463. Ecology
Prerequisites: introductory courses in biology and calculus.

A survey of adaptations to the physical environment, dynamics of natural populations, interactions between species, and human impacts on the environment.

465. Molecular Evolution
Prerequisite: introductory courses in biology, genetics, and evolution.

This course explores evolution at the molecular level. We use evolutionary principles to infer history from DNA sequences, to determine what forces have shaped the evolution of genes and genomes, to understand the relationship between molecular evolution and phenotypic evolution, and to address applied problems, like assigning biological function to genome sequences, finding the sources of epidemics, and finding the genes involved in human diseases.

466. Tree of Life
Prerequisite: none.

This course is centered around a survey of life’s diversity with an emphasis on understanding phylogenetic relationships, trends in diversity over macroevolutionary time, and the use of comparative methods to address topics such as adaptation and convergent evolution. Methods for reconstructing phylogenetic trees (e.g., neighbor-joining, parsimony, maximum likelihood, Bayesian) and the application of these trees to macroevolutionary questions are reviewed.

468. Laboratory in Molecular, Cell, and Developmental Biology
Prerequisites: courses in genetics, biochemistry, and molecular biology are highly recommended.

This course is designed to provide (1) introduction to model organisms, (2) training in specific methods used in molecular, cell, and developmental biology research, with emphasis on data acquisition and analysis, and (3) experience in the design and execution of experiments, reading and writing scientific reports, and public scientific presentation.

Prerequisite: none.

One of a four-course sequence that provides comprehensive coverage of advanced topics in ecology and evolutionary biology. Areas covered include population and community ecology; population and quantitative genetics; molecular evolution; evolutionary genomics; evo-devo; phylogenetics; and speciation.
This course is intended for graduate students; exceptional undergraduate students can enroll by permission of the course coordinator.

480. Graduate Laboratory Rotation  
Prerequisite: normally restricted to PhD candidates.
An introduction to research in the laboratories of individual faculty members.

516. Cell/Developmental/Molecular Biology Seminar
517. Graduate Research Seminar
580. Journal Club in Ecology and Evolution  
Prerequisite: permission of the instructor.
Current topics in ecology and evolutionary biology are explored by reading research and review papers. Students choose topics for reading and lead discussions of their chosen topics.

581. Topics in Cell, Developmental, and Molecular Biology  
Credit—two hours
This course is taught by all faculty members of the biology department that conduct research in the areas of cellular, developmental, and molecular biology. Each week one faculty member provides a general introduction to his or her field of interest and a comprehensive overview of his or her own research efforts. Short (one–two pages) papers are assigned throughout the course, critiqued, and returned for rewriting. Grades are determined by participation in class discussions and the assigned writings.

584. Seminar in Evolution
Biology Colloquium. Members of the staff and advanced students in the biological sciences meet on regularly announced dates for presentation and discussion of research by members of the department or invited guests. These meetings are open to all.

CELL BIOLOGY/MOLECULAR BIOLOGY
Several other courses in the field of cell and molecular biology are offered in the School of Medicine and Dentistry. See the section headed Interdepartmental Courses on page 182.

Brain and Cognitive Sciences
Professors Aslin, Bavelier, Chapman, DeAngelis (Chair), Ison, Jacobs, Knill, Lennie, Makous, Newport, E. Nordeen, K. Nordeen, Pouget, Supalla, Tanenhaus
Assistant Professors Cantlon, Hayden, Jaeger, Mahon, Tadin
Joint Appointments: Professors Allen, Carlson, Duffy, Haber, Klorman, Marvin, Merigan, Paige, Pasternak, Schieber, Williams; Associate Professors Bennetto, Huxlin, McDonough, Mink, O’Neill, Runner; Assistant Professor Gunlogson
Lecturer Miller
Professor Emeritus Kellogg

Members of the Department of Brain and Cognitive Sciences study how we see and hear, move, learn and remember, reason, produce and understand spoken and signed languages, and how these remarkable capabilities depend upon the workings of the brain. They also study how these capabilities develop during infancy and childhood, and how the brain matures and becomes organized to perform complex behavior.

The department offers a program of graduate study leading to the degree of Doctor of Philosophy. The PhD program emphasizes training in a range of research methods and concepts that drive the brain and cognitive sciences. While the focus is always on behavior and the brain activity that underlies it, students are encouraged to undertake projects in several laboratories that use different research methods, and to develop real expertise in some area of specialization.

The department’s research programs span a large domain in the behavioral, neural, and computational sciences. All of it is connected by the idea that to understand behavior we must study not only behavior but also the processes—both neural and computational—that underlie it. While the faculty have active research programs in many regions of this large domain, the department, in conjunction with the surrounding University community, has notable strength in the study of vision, natural language, cognitive neuroscience, computational modeling, and learning and plasticity during development.

The PhD curriculum has a core designed to introduce students to parts of the domain they might not previously have studied, and to prepare them for advanced work. This core curriculum covers a range of topics in perception, action, cognition, language, learning, and development, each examined from the perspectives of behavioral, computational, and neural science. The methods students master for approaching their own research may vary. However, as preparation for entering a highly interdisciplinary field, all students must acquire some expertise in at least two approaches. Students also take advanced courses and seminars in one or more areas of specialization. At all stages of their graduate careers, students are heavily engaged in research. Generally, students complete most of their coursework during the first two years. During the third year, students take a qualifying exam, covering the scholarly literature surrounding their area of specialization, and thereafter typically devote themselves fully to their
research. The PhD is awarded upon the completion of a dissertation containing original research in the field. The department does not offer a program leading to a master’s degree.

Students admitted to the program come from a variety of backgrounds, some in disciplines closely related to ours (e.g., psychology, neuroscience, computer science, cognitive science, linguistics), others in branches of the natural sciences or engineering that are less obviously relevant to our domain. This richness of backgrounds is a source of great strength to the program, because our students bring to it new ways of thinking about scientific problems. Although we do not stipulate the kinds of backgrounds students should have, we do expect applicants for admission to have outstanding academic records, and to be able to demonstrate their capacity for formal thinking and clear expression of ideas.

All students admitted to the program are offered graduate fellowships that provide a competitive 12-month stipend and cover the costs of tuition and other fees. Support is guaranteed for four years subject to satisfactory academic progress. The department does not distinguish teaching fellows and research assistants; all students are provided with a fellowship to support their research training, and all contribute to the department’s teaching by serving as teaching assistants or teachers of small classes. Students are asked to serve as teaching assistants for three courses during tenure of their fellowships. Where appropriate, students are encouraged to seek personal fellowships from bodies such as the National Science Foundation or the National Institutes of Health, for this brings distinction both to the student and the department; however, admission to the program is never contingent on students securing their own funds.

CORE COURSES

501. Language
An interdisciplinary introduction to the field of natural language, emphasizing behavioral, linguistic, and computational perspectives. Topics include language structure, production, comprehension, and acquisition.

502. Cognition
An interdisciplinary introduction to cognition. Topics include learning, memory, attention, concepts and categories, cognitive development, and reasoning, each considered from the perspectives of behavioral study, computational processes, and neural mechanisms.

504. Sensory Systems
An introduction to the functioning of the senses and the physiological mechanisms underlying them. Topics include vision, audition, somatosensation, the vestibular system, gustation, and olfaction, with an emphasis on the general principles that govern mammalian sensory systems.

505. Perception and Motor Systems
An interdisciplinary introduction to perception and action. Topics include the perception of motion, depth, surfaces, pattern and object perception, eye movements, motor planning and organization, and attention.

507. Basic Neurobiology
Explores fundamental concepts of neural organization and function. Covers gross and cellular neuroanatomy, neuronal cell biology, the electrophysiology of neurons and synapses, neurochemistry, spinal circuitry, sensory and motor systems, and higher functions including learning and memory. Includes labs on gross anatomy of the brain and computer simulation of neuronal electrophysiology.

507L. Basic Neurobiology Lab
This laboratory course is taken concurrently with the core lecture course, BCS 507. Seven laboratory sessions provide hands-on experience (brain dissection, cellular anatomy, electrophysiological recording) and demonstrations (behavioral pharmacology) to reinforce concepts introduced in the lecture course and to teach basic laboratory skills relevant to neuroscience.

508. Neural Plasticity in Learning and Development
Prerequisite: BCS 507 or equivalent.
An examination of neural plasticity in development as well as in adult learning and memory. Topics covered are approached from the joint perspectives of behavior, computational modeling, and neural mechanisms.

EXPERIMENTAL DESIGN, STATISTICS, METHODS COURSES

510. General Linear Approaches to Data Analysis I
Prerequisite: STT 211 or equivalent.
Issues of data analysis in experimental research. The course focuses on parametric techniques, especially analysis of variance. Topics include simple and complex designs for between and within subjects factors, including mixed designs; analysis of covariance and trend and contrasts. The course includes a lab in which students are taught to use a popular statistical package for data analysis.

511. Behavioral Methods in Cognitive Science
This course reviews the leading methods used to investigate cognitive skills and/or their neural substrates in humans. The course is divided into several sections: accuracy and psychophysics; RT and processing states; interference, neighborhood effects, and system dynamics; investigations of natural data; brain imaging methods as applied to the cognitive sciences; and issues when studying special populations such as infants, patients, animals, or any noncompliant subject. Technical articles on each technique are discussed in combination with specific illustrations of how each has been used to investigate research questions.
512. Computational Methods in Cognitive Science
This course examines mathematical/computational models of visual perception, decision making, learning, and movement control. The objective is to develop technical knowledge and skills needed to formulate, evaluate, and understand such models.

513. MR Imaging: From Spins toBrains
This course introduces students to the physics of MR imaging and reviews its application to medical imaging. We discuss how the MR technique can take advantage of physiological principles and tissue structure to provide diagnostic images for clinicians and researchers. We then cover what can be learned about brain functions through MR imaging. In particular, students are introduced to functional brain imaging and related issues in data analysis. The goal of the class is to provide students with a comprehensive background of the MR imaging technique and its application to medical or research issues.

514. Laboratory in Neurobiology
Prerequisite: BCS 507 or equivalent.
This course introduces various methods used in neurobiological research. Structured laboratory experiments provide experience with neuroanatomical, neurochemical, neuropharmacological, and neurophysiological approaches to studying neural organization and function. During an extended project, students carry out stereotaxic surgery, collect behavioral measurements, process neural tissue for microscopic analysis, collect anatomical data, and produce a final research paper.

GRADUATE COURSES IN COMPUTATIONAL SCIENCE
532. Advanced Computational Methods in Cognitive Science
Prerequisite: BCS 512 or equivalent.
This course focuses on advanced methods for modeling cognitive, perceptual, and neural phenomenon, and for analyzing and revealing regularities in experimental data. Topics may include maximum likelihood and Bayesian estimation, information-theoretic analyses, neural networks, graphical models, clustering, dimensionality-reduction, and unsupervised and supervised learning.

533. Statistical Speech and Language Processing
Prerequisites: CSC 172 and either CSC 240 or CSC 242.
An introduction to statistical natural language processing and automatic speech recognition techniques. This course presents the theory and practice behind the recently developed language processing technologies that enable applications such as speech-driven dictation systems, document search engines (e.g., finding Web pages), and automatic machine translation.

535. Natural Language Processing
Prerequisite: CSC 242.
Introduction to computational linguistics: constructing computer programs that understand natural language. Topics include parsing, semantic analysis, and knowledge representation.

536. Machine Vision
Prerequisites: CSC 242 and MTH 161.
Introduction to computer vision, including model-based vision, projective invariance, Hough transforms, pattern recognition and neural nets, color theory, texture, and optic flow.

GRADUATE COURSES IN COGNITIVE NEUROSCIENCE
541. Integrative and Systems Neuroscience
Prerequisite: BCS 507 or equivalent.
Provides a critical overview of current approaches to the study of systems neuroscience. Topics include connectivity, neurophysiology,
and behavioral measures of sensory and motor systems, memory, and attention.

542. Neuropsychology
Examines clinical neuropsychology, which bridges neurology, neuroscience, and clinical psychology. Covers history of clinical neuropsychology, principles of neuropsychological assessment and the interpretation of cognition and behavior as they relate to brain dysfunction. Considers specific neurological syndromes.

543. Neurochemical Foundations of Behavior
Prerequisite: BCS 507 or equivalent.
Introduces the field of neurochemistry with an emphasis on cellular and molecular neurochemistry. Topics range from study of neurochemical mechanisms that underlie normal neural function to discussion of behavioral disturbances that result from neurochemical abnormalities. Considers neurochemical mechanisms of adaptive behavior, learning and memory, behavioral disorders, gender differences and drug-seeking behavior.

546. Biology of Mental Disorders
Examines the neurobiology of anxiety/phobic conditions, mood disorders, and chronic psychotic states, particularly schizophrenia. Considers definitions of psychiatric syndromes, the problems of diagnosis, brain organization, and neurotransmitter systems involved in "state" functions. Introduces research approaches including epidemiologic, phenomenologic, family/adoption, longitudinal descriptive, psychophysiology, neuro-psychopharmacologic, genetic linkage, and postmortem studies; emphasizes recent in vivo brain imaging and neuroreceptor studies.

547. Introduction to Computational Neuroscience
Prerequisite: graduate standing in BCS, NSC, or CS, or permission of instructor.
A review of recent progress in computational theories of the brain, emphasizing theories of representation and computation in neural circuits. The course begins with biophysical models of neurons and ends with models of complex cognitive functions, such as sensory motor transformations or sentence processing.

548. Advanced Seminar on Plasticity
Prerequisite: BCS 508 or permission of instructor.
The goal of this seminar is to cover the latest advances on brain plasticity. A wide range of topics is covered, including molecular, cellular, and system-level mechanisms of brain plasticity in animal models as well as humans. All participants are expected to have a good command of the basic principles of neural development and plasticity.

549. Developmental Neurobiology
Prerequisite: BCS 507 or equivalent.
The organization of our nervous system defines the ways we behave, perceive, think, and feel. This course explores factors that influence the differentiation and survival of nerve cells, the functional specialization of neural regions, how axons navigate to targets and accurately map connections within these targets, and how connections are influenced by early perceptual and hormonal experience. Examples of developmental plasticity are compared and contrasted with forms of neural plasticity normally exhibited in adults.

GRADUATE COURSES IN LANGUAGE AND COGNITION

550. Development of Mind
A survey of the major topics and issues in development. The course covers the development of sensation, perception, cognition, and language in humans, as well as the development of neural mechanisms and systems in other species. A major theme involves the nature/nurture issue, including the interacting roles of experience and maturation, the constraints on plasticity provided by maturation (for example, in critical period phenomena), and the differences and similarities between development and learning.

555. Language Acquisition
The course covers a broad range of topics on the child's acquisition of a native language, including literature on the acquisition of spoken and signed languages, as well as theories of the language learning process. Focus is on the acquisition of syntax and morphology.

558. Music and the Mind
Prerequisite: previous music theory study (equivalent to TH 115 and TH 116) or permission of instructor.
Introduction to the discipline of music cognition. Topics include empirical methods, psycho-acoustic principles, Gestalt psychology, music and language, metric and tonal hierarchies, music and the brain, musical development, and research on memory, expectation, and emotion. Students are responsible for readings, discussion, midterm exam, and a major research paper.

560. Proseminar in Music Cognition
This course is intended both as a survey of primary research in the field of music cognition and as a "laboratory" course in experimental method. Students discuss and critique experimental studies published in journals. In addition, the class works collaboratively to build skills in experimental design and data analysis via a "methods" textbook and class demonstrations/activities. Each student is expected to design and run an experiment as a final project.

561. Speech Perception and Recognition
Provides an overview of the theories and empirical findings on human speech perception and recognition. Topics include an overview of phonetics, categorical perception, speech perception by nonhumans and by human infants, perception of nonnative speech sounds, intermodal perception of speech, and word recognition in fluent speech.

562. Language Production
Covers current and classic topics in the field of language production. Topics include speech error models, computational models of lexical/phonological encoding, issues in syntactic encoding,
the incrementality of speech production, comprehension vs. production, and hearer vs. speaker-oriented accounts of production processes.

563. Topics in Language Production and Comprehension
This seminar offers an in-depth examination of selected topics in language comprehension, including lexical processing, parsing, and anaphora resolution. Theoretical ideas from linguistics and artificial intelligence are integrated with experimental studies of language processing.

564. Signed Language Structure
An examination of signed languages and the cognitive constraints that shape them, through a detailed consideration of the structure of American Sign Language and other natural signed languages of the world. Includes training in sign language notation and analysis.

565. Language and the Brain
This course examines how the comprehension and production of language is implemented in the human brain. It focuses on spoken language (not written or signed language) and fMRI (not ERPs and other imaging modalities). A number of questions about brain activation to speech vs. nonspeech/music; native vs. nonnative phonetics/phonology; effects of learning/expertise; lexical organization (neighborhood structure) and development; form-class and semantic category constraints on processing; and the role of perceptual brain regions in semantic processing are considered. The course also explores new fMRI analysis methods and experimental designs that could be suitable for addressing these questions.

566. Topics in Understanding Language
This seminar focuses on selected topics in language processing. The specific topic for a particular year to be announced. For graduate students and faculty in the language sciences.

568. Sign Language Universals and Typology
Crosslinguistic comparisons among signed languages, considering the possible linguistic universals for signed languages, the degree and types of variation among different signed languages, the ways in which universals and language specific variation for signed languages may compare and contrast to those for spoken languages, and the visual, motoric, and cognitive constraints which may give rise to these phenomena.

569. Sign Language Psycholinguistics and Acquisition
Consideration of the processing, historical development, and acquisition of signed languages, with an interest in the ways that language processing, development, and evolution may affect language structure.

581. Music and Language
This course explores relationships between musical and linguistic structure and discusses experimental work on prosodic structure in language and on music acquisition in infants. The course reviews basic aspects of phonology, intonational phonology, meter, and memory that are relevant to music.

582. Grant Writing in Brain and Cognitive Sciences
A grant writing workshop designed to train students to prepare effective and successful research grant proposals in the field of brain and cognitive sciences. Students participate in a mock scientific review panel to review sample grant proposals. They also prepare an NIH NRSA proposal through a process of peer critique and revision.

599. Professional Development and Career Planning
The purpose of this course is to provide first- and second-year graduate students with a set of guiding principles for optimizing their progression through the PhD program. The following topics are discussed: fulfilling program requirements, advising and mentoring, time management, conference presentations and journal publications, writing skills for journals and grants, how to juggle, persist, drop, and collaborate in your research projects, the post-PhD job market and qualifications required for success.

OTHER COURSES

591. Readings at the PhD Level
595. Research at the PhD Level
598. Supervised Teaching
999. Doctoral Dissertation
Chemistry

Professors Boeckman (Chair), Bren, Dinnocenzo, Eisenberg, Farrar, Goodman, Holland, Jones, Krauss, Krugh, Prezhdo, Rothberg, Schröder, Turner
Associate Professor Frontier
Assistant Professors Fasan, McCamant, Neidig, Nilsson, Weix Professors (Research) Conwell, Eisenberg, Farid
Joint Appointment: Professor Tang
Cluster Members: Professors DeLouise, Ermolenko, Grossfield, Kielkopf, Krysan, Mathews, Miller, Mukaibo, Phizicky, Shes-topalov, Wedekind
Professors Emeriti Huizenga, Kende, Kreilick, Muenter, Saunders

The Department of Chemistry concentrates on programs leading to the PhD degree. The Chemistry Graduate Studies Office maintains a booklet with the complete descriptions of departmental requirements for the PhD degree. Departmental information can be found at www.chem.rochester.edu and requirements for the PhD degree can be found at www.chem.rochester.edu/graduate/phd.html.

The registrar’s list of courses should be consulted to determine which ones are being offered in the current year. Not all of these courses are offered each year. All courses carry four credit hours unless otherwise noted. Some “modular” courses carry two credit hours and are offered during the first or second half of given semesters as indicated.

402. Biophysical Chemistry I
Introduction to the theory and application of NMR, as used in biochemical problems. (Spring, even years)

404. Biophysical Chemistry II
Explores how fundamental interactions determine the structure, dynamics, and reactivity of proteins and nucleic acids. Examples are taken from the literature with emphasis on thermodynamics, kinetic, theoretical, and site-directed mutagenesis studies. (Spring, odd years)

405. Interface of Chemistry and Biology
Provides an introduction to recent research at the interface of chemistry and biology by focusing on seminars given in various departments. (Spring)

411. Inorganic Chemistry I
Descriptive chemistry of main group elements, bonding in inorganic systems, coordination chemistry, and the properties and reactions of transition metal complexes. (Fall)

414. Bioinorganic Chemistry
Prerequisite: CHM 411, or 211 with permission of instructor.
Principles of inorganic chemistry relevant to living systems. Topics include acquisition and utilization of trace metals, enzyme mechanisms, metal toxicity, and bioinorganic spectroscopic techniques. (Spring)

415. Group Theory
Credit—two hours
Development of symmetry and group theory concepts and scope of applications to chemical problems. (Fall, first half of semester)

416. X-Ray Crystallography
Credit—two hours
Basic principles of X-ray diffraction, space group symmetry, single-crystal data collection, and solution of small molecule structures. (Spring, second half of semester)

421. Basic Organometallic Chemistry
Credit—two hours
Examination of the concepts, systems, reactions, and applications of organometallic chemistry. Structure and bonding of complexes having carbonyl, alkyl, carbene, olefin, CnHn, and related pi ligands. Oxidative addition, insertion, elimination reactions, and other fundamental reactions of organometallic compounds. (Fall, second half of semester)

422. Organometallic Chemistry
Prerequisite: CHM 421.
Credit—two hours
Mechanisms in organometallic reactions. Applications of organometallic compounds in homogeneous catalysis, polymerization, metathesis. (Spring, first half of semester)

423. NMR Spectroscopy
Credit—two hours
A description of the most important NMR topics and methods in modern FT NMR spectroscopy, including the vector model, pulses, coupling, spin-echoes, relaxation, phase detection, window functions, tuning, shimming, and 1D and 2D techniques. APT, INEPT, DEPT, COSY, INADEQUATE, HMOC, HET-COR. Practical aspects of recording spectra are also included. (Fall, first half of semester)

425. Physical Methods in Inorganic Chemistry
Prerequisite: CHM 411.
Credit—two hours
Molecular and electronic structure determination of inorganic compounds and metal complexes; spectroscopic and physical methods. (Fall, second half of semester)

427. Organic Structure Determination
Prerequisite: CHM 422.
Credit—two hours
The modern methods and tools employed for the determination of the structure of complex organic molecules are discussed. Among the areas discussed in detail are NMR (1D and 2D), IR, UV, and mass spectroscopy. Problem-solving techniques are illustrated and problem-solving skills developed by means of problem sets and class examples. (Fall, second half of semester)
**433. Advanced Physical Organic Chemistry I**  
Quantum chemistry and bonding. Woodward-Hoffman rules, spectroscopic techniques, and photophysical processes. (Fall)

**434. Advanced Physical Organic Chemistry II**  
Structure and reactivity; kinetics, catalysis, medium effects, transition state theory, kinetic isotope effects, photochemistry, reactive intermediates, and mechanisms. (Spring)

**435. Organic Reactions**  
A survey of reactions of organic substances with emphasis on those with practical synthetic utility, including discussion of mechanism, scope and limitations, and stereochemical issues. (Fall)

**436. Applications of Organometallic Chemistry to Synthesis**  
Prerequisite: CHM 421.  
Credit—two hours  
The transition metal-mediated organometallic reactions most commonly employed in organic synthesis are discussed including their substrate scope, mechanism, and stereo- and/or regiochemical course. Emphasis is placed on the practical aspects such as catalyst and reaction condition selection and protocols for trouble shooting catalytic cycles. (Spring, first half of semester)

**438. Synthetic Design: Strategy and Tactics**  
Prerequisite: CHM 425.  
Credit—two hours  
A formalism describing commonly employed strategies and tactics for the analysis of complex problems in organic synthesis is presented. Examples of such strategies are compared and contrasted during discussion of published complex molecule syntheses. (Spring, second half of semester)

**440. Bioorganic Chemistry and Chemical Biology**  
Principles involved in the design of organic molecules for recognition and catalysis in biological systems. Molecular shapes and conformations; noncovalent bonding; catalysis; drug design principles. Hands-on computer molecular modeling. (Spring)

**441. Advanced Physical Chemistry I**  
Introduction to quantum mechanics with applications to spectroscopy and to atomic and molecular structure. (Fall)

**444W. Advanced Nuclear Science Educational Laboratory (ANSEL)**  
This course develops a sophisticated understanding of our terrestrial radiation environment and of some of the important applications of nuclear science and technology. Course includes practical skills in the routine use of radiation detectors, monitors, and electronics to assess radiation threats and prospects of their abatement. The four in-depth ANSEL experiments are designed to help re-create a type of well-rounded, competent experimental nuclear scientist who is able to analyze an experimental problem; to select, design, and set up appropriate nuclear instrumentation; and to conduct required measurements. (Spring)

**451. Quantum Chemistry I**  
Introduction to quantum chemistry covering quantum mechanical principles, simple systems, atoms, molecules, and spectroscopy. (Fall)

**452. Quantum Chemistry II**  
Prerequisite: CHM 451.  
Heisenberg representation, advanced theories of electronic structures, angular momentum, perturbation theory, scattering theory, and semi-classical techniques are covered. (Spring)

**455. Thermodynamics and Statistical Mechanics**  
Introductory statistical mechanics and thermodynamics with applications, computer simulations. (Fall)

**456. Chemical Bonds: from Molecules to Materials**  
Introduction to the electronic structure of extended materials systems from both a chemical bonding and a condensed matter physics perspective. The course discusses materials of all length scales from individual molecules to macroscopic three-dimensional crystals, but focuses on zero-, one-, and two-dimensional inorganic materials at the nanometer scale. Specific topics include semiconductor nanocrystals, quantum wires, carbon nanotubes, and conjugated polymers. (Spring)

**458. Molecular Spectroscopy and Structure**  
Prerequisites: CHM 451 or CHM 251 and CHM 222 or permission of instructor.  
Rotational, vibrational, and electronic spectroscopy of diatomic and polyatomic molecules. Symmetry and group theory. Nonlinear laser spectroscopy and magnetic resonance. (Spring, first half of semester)

**460. Chemical Kinetics**  
Prerequisite: CHM 451.  
Credit—two hours  
An introduction to the microscopic approach to chemical reactions, including rate laws and elementary reactions, potential energy surfaces and molecular collision dynamics, photodissociation, and energy transfer. (Spring, second half of semester)

**462. Biological Chemistry**  
An introduction to biological chemistry. Topics covered include protein and nucleic acid structure, recombinant DNA technology, bioenergetics, enzyme kinetics and mechanism, and intermediary metabolism. Lectures are supplemented with workshops. (Spring)

**465. Nuclear Science and Technology I**  
Introduction to the structure of nuclei and nuclear interactions; experimental and theoretical techniques of nuclear science; interaction of
radiation with matter; gross properties of stable nuclei; laws of gamma and particle decay of unstable nuclei; nuclear forces and symmetries; single-particle and collective nuclear models; general aspects of nuclear reactions, nuclear thermodynamics. (Fall, every odd year)

470. Computational Chemistry
In this course, students learn about a range of computational methods used to attack research problems in chemistry. Emphasis is placed both on the theory underlying computational techniques and on their practical application. Topics include molecular mechanics, ab initio electronic structure theory, density functional theory, molecular dynamics and Monte Carlo simulations, methods for free-energy calculations, path-integral techniques, and methods for protein structure prediction. (Spring)

511. Chemistry Seminar
Credit to be arranged
Required of all graduate students in physical, inorganic, and biophysical chemistry during each semester they are registered. (Fall and Spring)

513. Chemistry Colloquium
Credit to be arranged
Required of all graduate students in organic chemistry during each semester they are registered.

566. Nuclear Chemistry II
Experimental and theoretical studies of heavy-ion scattering and reaction mechanisms; semi-classical and quantal scattering theory; Coulomb excitation; few-nucleon transfer; damped heavy-ion reactions; fusion and fission processes; statistical approaches to complex nuclear reaction mechanisms. (Spring, every even year)

583. Advanced Chemistry Seminar and Colloquium
Credit—none

585. First-Year Graduate Workshop
Credit—one hour
Pedagogy in chemistry graduate school.

591. Reading Course at the PhD Level
Credit to be arranged

593. Special Topics in Chemistry
Credit—two hours
Advanced topics of current interest.

594. Internship

595. Research at the PhD Level
Credit to be arranged
Research projects chosen by students, limited only by the research interests of the faculty.

899. Master’s Dissertation
Credit—none

997/999. Doctoral Dissertation
Credit—none
Full-time registration category for students who have completed 90 credit hours.
Clinical and Social Sciences in Psychology

Professors Davies, Deci, Elliot, Korman, Reis, Ryan, Smetana, Zuckerman
Associate Professors Bennetto (Chair), Rogge, Tioth
Assistant Professors Burnette, Sturge-Apple
Joint Appointments: O’Connor, Rogosch, Todd-Manly, Williams, Willis, Wyman
Professors Emeriti Ilardi, McAdam, Wheeler, Zax

The Department of Clinical and Social Sciences in Psychology offers programs of study leading to the PhD degree in three areas of psychology: clinical psychology, social-personality psychology, and developmental psychology. An interdisciplinary program in human motivation cuts across the clinical and social-personality areas. Students interested in this interdisciplinary area should apply development to the clinical, developmental, or social-personality program, and note in their application their strong interest in motivation. The doctoral program requires a minimum of four years of study. The master’s degree can be obtained en route to the PhD by passing the qualifying examination for the PhD. However, students seeking only the master’s degree are not admitted.

Although each area program is flexible, all programs are designed to prepare students to do research. Upon entering the department, students are appointed a faculty member to advise them on selection of courses and to provide an introduction to research opportunities. Satisfactory progress through the program depends on completion of both coursework and research requirements. Coursework seeks to provide the broad base of knowledge needed for research, including courses outside the students’ areas of specialization. Although the department places strong emphasis on research training, we believe that students should also have teaching experience. All students, therefore, assist in the teaching of at least one undergraduate course (e.g., leading a discussion section, conducting individual tutorials, or assisting in laboratory classes). At the end of their third year, students take the PhD qualifying examination. Passing this exam establishes that the students have a comprehensive grasp of fundamental knowledge in their major areas, and are prepared to undertake dissertation research.

The program in clinical psychology has been accredited continuously since 1948 by the American Psychological Association (Office of Program Consultation and Accreditation, American Psychological Association, 750 First Street, NE, Washington, DC 20002; phone: (202) 336-5979; website: www.apa.org/ed/accreditation). The program follows the clinical-scientist model and prepares students for teaching and research positions as well as professional activities with adults and children. Major emphasis is placed on research and scholarly training. Diverse areas of specialization are available, most notably: (1) developmental psychopathology, (2) motivation, and (3) neuroscience. A major resource for training and research is the Mt. Hope Family Center.

Graduate students in the clinical psychology program receive training in both general and clinical psychology. A sequence of courses provides training in psychometrics, individual differences, psychopathology, cognitive bases of behavior, social bases of behavior, biological bases of behavior, scientific and professional ethics, cultural and ethnic diversity, history and systems of psychology, research design, methodology, and statistics. In addition, graduate students in the clinical psychology program must complete an internship, which may begin only after the second year of residency and satisfactory completion of major comprehensive examinations. The internship must consist of a minimum of 1,750 hours in either a block or distributed format at an agency or combination of agencies approved by the department. Only placements of at least 16 hours per week and lasting a minimum of 26 weeks are acceptable.

The social-personality psychology program provides training for both laboratory and field research. Among the research topics currently featured are achievement motivation, self-determination, social cognition, social interaction, interpersonal processes in close relationships, social psychology of health, and emotion. Innovative research and quantitative methods are emphasized.

The developmental psychology program prepares students for careers in research and teaching and provides students with the theoretical perspectives and methodological skills needed for advanced scholarly work. Topics currently being researched include emotion recognition, interparental processes and their effects on children, child and family steps to enhance school preparedness and success, moral development, adolescent-parent relationships, neurocognitive processes in developmental disabilities, development of romantic relationships, and the development and maintenance of resilient outcomes among high-risk children. Opportunities for research are also available through involvement at the Mt. Hope Family Center and the Children’s Institute.

The program in human motivation includes faculty and students from social-personality and clinical psychology. It has two major foci. The first is concerned with the nature and development of self-determination, the regulation of behavior, and the internalization of values and goals. Participants working with this focus conduct basic research in the laboratory, as well as field research in areas such as health care, education, and organizations. The second focus is on achievement motivation, using a goals and approach-avoidance perspective. This work also involves both laboratory and field research, particularly in education.

The department is housed in Meliora Hall, a building with well-equipped laboratories, seminar and teaching rooms, and technical facilities needed to support teaching and research. The department also cooperates and shares facilities with the Mt. Hope Family Center, the Departments of Psychiatry and Pediatrics, and area hospitals, schools, and industrial settings. Psychologists and professionals from other disciplines cooperate to further the objectives of the graduate program. The department offers excellent computing facilities and maintains a computer lab/classroom devoted for departmental use. Licenses for statistical analysis software such as SPSS and Amos are
maintained for use on the lab machines. In addition to its own facilities, members of the department have access to the many resources of the University’s various computing centers.

The department supports students through fellowships, traineeships, and teaching and research assistantships. Teaching and research assistantships typically call for 15 to 20 hours a week under faculty supervision.

Interested students can find all pertinent information describing graduate study in clinical, social-personality, and developmental psychology in the graduate section of the departmental website: [www.psych.rochester.edu/graduate](http://www.psych.rochester.edu/graduate). However, if after reviewing this information you have specific questions about the program, please contact our Academic Coordinator (see website).

The department’s undergraduate and graduate courses are listed below. Although courses with 200 and 300 numbers are primarily for undergraduates, they can be approved for three hours of graduate credit by the student’s advisor.

### LABORATORY COURSES

211. Introduction to Statistical Methods in Psychology

219W. Research Methods in Psychology

266. Research Laboratory in Social Psychology

351. Research in Developmental Neuropsychology I

352. Research in Developmental Neuropsychology II

356. Research in Adolescent Development

373. Exploring Research in Social Psychology I

374. Exploring Research in Social Psychology II

377. Exploring Research in Family Psychology I

378. Exploring Research in Family Psychology II

### ADVANCED LECTURE COURSES

262. Human Motivation and Emotion

263. Relationship Process and Emotions

264. Industrial and Organizational Psychology

267. Psychology of Gender

278. Adolescent Development

280. Clinical Psychology

281. Psychology and the Law

282. Abnormal Psychology

283. Behavioral Medicine

289. Developmental Childhood Psychopathology

### SEMINAR COURSES

301. Teaching Psychology

361. Social Psychology: Self-Concept

362W. Seminar in the Psychology of Gender

364. Achievement and Motivation

368W. Seminar in Humanistic Psychology

371. Seminar in Social & Personality Development

375. Advanced Topics: Relationships & Emotions

376. Seminar in Self-Determination

381. Psychology of Developmental Disabilities

383. Moral Development

384. Practicum in Developmental Disabilities I

385. Practicum in Developmental Disabilities II

386. Advanced Emotional Development

388. Research Practicum in Developmental Psychopathology I

389. Research Practicum in Developmental Psychopathology II

396. Seminar in Special Topics

The 500-level courses listed below carry three credit hours, except as noted.

501. Ethical Issues in Clinical Psychology

Psychologists have multiple sets of responsibility with information, and these are defined in this course. Individual’s rights to privacy underlie ethical principles of confidentiality and the legal concept of privileged communication; informed consent requires that disclosure to a psychologist occur in circumstances that are regulated and mutually understood. Under specific situations, defined ethically or legally, information may or must be shared with others. Through readings and discussion, the course examines the ethical, professional, and legal principles that govern the use of information in practice, teaching, and research in psychology.
502. Cognitive Foundations
Knowledge of cognitive science, theories of learning, memory, and factors that influence an individual’s cognitive performance. Current theories and research in classical and operant conditioning, learning, memory and attention, psychophysics, masking, signal detection theory, language, issues, and emerging methodologies in cognitive science.

504. General Linear Approaches to Data Analysis I
Issues of data analysis in experimental research. The course focuses on parametric techniques, especially analysis of variance. Topics covered include simple and complex designs for between and within subjects factors, including mixed designs; analysis of covariance and trend and contrasts. The course includes a lab in which students are taught to use a menu-driven version of SPSS for data analysis.

509. Seminar in Psychotherapy

510. Research Methods in Psychology
Discussion of research design, reliability, validity, and related topics in the first part. Consideration of data analysis with particular emphasis on analysis of variance, contrast analysis, and meta-analysis in the second part.

514. Structural Equation Modeling
Course covers statistical techniques that comprise Structural Equation Modeling: confirmatory factor analysis, path analysis, and hybrid models (which include latent factors and the structural paths among them). The class covers introductory material (e.g., identification and estimation) as well as some intermediate and advanced topics (e.g., measurement invariance and interactions between latent variables). Previous knowledge of regression is highly recommended.

515. Hierarchical Linear Modeling
This course covers the basic theory and equations underlying multilevel modeling techniques for analyzing hierarchical data. Lectures on the underlying statistics are paired with detailed in-class data analysis examples and hands-on homework sets to ensure that students leave the class fully competent to run and thoroughly interpret their own HLM analyses.

519. Data Analysis: General Linear Applications
Topics include multiple regression, structural equations (e.g., path analysis), and multivariate techniques. The emphasis is practical, focusing on the analysis of actual psychological data.

549. Psychology of Dual Processing
This course examines implicit and explicit processes in various realms of personality and social psychology: those include self-esteem, attitudes, stereotypes, and goal pursuit. The methodology used to measure implicit processes, the amount of overlap between implicit and explicit aspects of the same construct, and the psychological implications of discrepancies between implicit and explicit processes (e.g., implicit and explicit self-esteem) are among the topics discussed.

550. Social Psychology of Emotion
This seminar covers social psychological research on the nature and expression of emotion. Topics include situational determinants, emotion regulation, individual differences, and the antecedents of specific emotions.

551. Social Cognition
Review of theory and research in two areas: judgment under uncertainty and social attribution. Particular focus on cognitive biases and their effects on perception, probability estimates, and attribution. The relationship between cognition and motivation is also discussed.

552. Human Motivation and Emotion
The course focuses on the current field of human motivation and emotion, reviewing various theories and research programs, and covering related work in personality, cognition, learning, and performance, including operant and drive theories.

553. Seminar in Social Psychology
An advanced overview of the field. Attitudes, interpersonal influence, attraction, aggression, social comparison, leadership, prejudice, and methodology.

555. Close Relationships
Development, maintenance, and dissolution of friendships and intimate relationships. Theoretical and empirical perspectives.

556. Social Psychology of Control
The concept of control—its antecedents, correlates, and consequences—is reviewed. Theoretical and empirical works from the field of developmental psychology, personality, and social psychology serve as reading materials. Examples of topics are helplessness, need for control, perceived control, efficacy, and Type A behavior.

557. Seminar in Interpersonal Development
Takes a developmental psychopathology perspective in exploring the linkages between adaptive and maladaptive interpersonal relations and children’s development over the first two decades of life. Examples of topics include family relations and psychopathology (e.g., depression, alcoholism), quality of peer relationships, friendships, adolescent romantic relationships, and the interplay among these relationship domains.

559. Motivational Research
A seminar that meets weekly to discuss ongoing research on self-determination theory. Limited to doctoral students in the motivation program, with the permission of the instructor.

560. Family Processes in Childhood
Covers the developmental psychopathology of family relationships with a specific focus on how parent-child, interparental, and sibling relationships play a role in the development of children’s psychological adjustment and maladjustment. Current directions in empirical research, theory, methodology, and their interplay are emphasized.
**561. Topics in Social Psychology Research**
Covers topics in social psychological research and careers.

**562. Developmental Research Methods**
The goal of this course is to address the nature of different developmental methods and designs and their application to different programs of research, especially as they pertain to central disciplinary issues of stability and change in development. Course curriculum covers characteristics of measurement and methodology (e.g., questionnaires, interviews, observations, developmental assessments), research design (e.g., experiments, quasi-experiments, naturalistic and field research), and analytic models (e.g., multivariate, developmental).

**564. Clinical Assessment of Developmental Psychopathology**
Advanced seminar covering assessment and diagnosis of developmental disorders across the lifespan. Topics will also include an introduction to neuropsychological assessment and a review of selected treatment strategies.

**566. Neurobiological Foundations**
This course provides an overview of brain behavior relationships. The course covers historical and theoretical concepts in neuroscience and neuropsychology, the evolution of the primate brain, the organization and functions of the human nervous system, neural development, genetic and environmental influences and plasticity, basic cortical and subcortical structures and the disorders that result from their damage, and principles of neuropsychological assessment.

**568. Psychology of Health**
Among the topics to be examined are factors affecting longevity, positive illusions and well being, the relation between loneliness and health, coping, and gender and health. The readings mostly reflect social psychology- or personality-related research.

**569. Developmental Theory and Research**
This course focuses on the theoretical underpinnings of developmental psychology and its implications for current directions in research. The interplay between developmental philosophy, theory, research, and application are addressed, particularly as they apply to current theoretical and research directions in developmental psychology.

**570. Clinical Assessment I: Psychometrics**
Prerequisites: departmental acceptance for professional clinical training, and statistics (may be taken concurrently).

The purpose of this course is to develop an understanding of psychometric theory and its application to assessment. The course focuses on the following issues: assessment theory, types of tests, test construction and standardization, reliability, validity, test fairness, and ethical and social considerations in testing. Students learn the psychometric characteristics of a variety of widely used assessment instruments and acquire skills in the administration, scoring, and interpretation of these instruments.

**571. Clinical Assessment II: Individual Differences**
The purpose of this course is to develop a conceptual understanding of personality, aptitudes, and interests. The course focuses on the following issues: comparative theories of personality, descriptive psychopathology, quantitative assessment of interests, personality and psychopathology, projective assessment of personality, and group differences related to age, sex, race, and ethnicity in a variety of domains. Students apply the principles of quantitative assessment and acquire skills in the administration, scoring, and interpretation of a variety of assessment instruments.

**572. Introduction to Clinical Research Methods**
This course explores an array of methodological issues facing clinical psychology researchers—measure development and validation, sampling effects, power and type II error, efficacy vs. effectiveness, clinical vs. statistical significance, effects of method variance and nonspecific treatment effects—providing a solid foundation in experimental design.

**573. Issues in Cultural Diversity**
Current topics in psychological differences based on cultural, ethnic, socioeconomic, physical disabilities, and sexual orientation.

**574. History and Systems of Psychology and Psychotherapy**
This course surveys and compares philosophical frameworks underpinning schools of psychological thought. Pioneers and leaders in psychology are studied from a historical point of view. Systems of thought underlying approaches to psychotherapy and behavior change, including psychodynamic, existential-phenomenological, Eastern behavioral, and cognitive, are especially emphasized. Critical discussion focuses on the cultural historical contexts as well as the impact of the contribution of the various approaches on other sciences and social, political, cultural, educational, and gender issues.

**575. Psychopathology I**
Examines psychopathology of childhood and adulthood from a developmental perspective that encompasses the study of both normal and abnormal development. Topics covered include taxonomic, definitional, and epidemiological issues; mental retardation; autism; child maltreatment; affective disorders; schizophrenia; resilience; and ethical considerations in conducting research.

**576. Psychopathology II**
Continuation of CSP 575. Examines general issues of taxonomy of psychopathology; anxiety, disruptive, substance use, psychophysologic, and substance use disorders of childhood, adolescence, and the adult years. The course covers research on description, epidemiology, psychologic deficits, and treatment approaches to these disorders.
577. Research Seminar in Motivation
An advanced graduate seminar that addresses issues related to methods of research in motivation, as well as discussion of theory and application. (Spring)

582. Practicum in Developmental Psychology
Prerequisite: CSP 586 or permission of instructor.
This practicum is designed to build upon CSP 586, “Evidence-Based Child Psychotherapy.” Students are exposed to a number of evidence-based models of therapy, including cognitive-behavioral therapy, child-parent psychotherapy, Interpersonal Psychotherapy, PATHS, and Incredible Years Parenting groups. Depending on prior experience and interests, the child case assignments and therapeutic modalities utilized are tailored to individual student goals. Class meetings involve the review of videotaped client sessions.

583. Moral Development
The purpose of this seminar is to examine major theoretical and empirical approaches to moral development. We examine and contrast major theories of moral and pro-social development, including psychoanalytic theories (primarily Freud), cognitive-developmental theories (Piaget, Kohlberg, Turiel, and Eisenberg), and socialization theories. We consider research methods and empirical findings within each approach and discuss the applicability of theories cross-culturally. The primary focus of the course is on psychological approaches to moral development, but we also consider philosophical and applied (e.g., educational) issues.

584. Psychotherapy Practicum I

585. Psychotherapy Practicum II

586. Evidence-Based Child Psychopathology
The overarching objectives of this course include (1) to expose students to historical and current issues with respect to the provision of evidence-based treatments and to examine the research that has contributed to the “support” of various treatments; (2) to examine a number of evidence-based treatments, including cognitive-behavioral therapy, interpersonal psychotherapy, child-parent psychotherapy, and Incredible Years parenting groups. Discussions of these manualized treatments are supplemented with audio- and videotapes of actual clinical cases. NOTE: Enrollment is limited to the department’s graduate students.

587. Overview of Marital Research
This is a survey course exploring the highlights of nearly 30 years of marital and relationship research. The course examines topics including communication behavior, attributions, social support, personality factors, adult attachment, transition to parenthood, and violence in relationships. The course also examines the literature on predicting marital outcomes as well as the divorce prevention literature and the marital therapy literature.

588. Clinical Preceptorial

589. Gestalt Therapy
Experiential training in group psychotherapy, with emphasis on the Gestalt approach. Intended for clinical psychology graduate students in their second year or above, but may be open to others with permission of the instructor.

591. Reading Course at the PhD Level
Credit—normally three hours, upon approval from the Dean’s Office

593. Special Problem
Prerequisite: permission of instructor.
Credit to be arranged
The investigation, under guidance, of a special problem in experimental psychology and the presentation of the results of this research in a paper.

595. Research at the PhD Level
Credit to be arranged

598. Seminar in Teaching
Readings, preparation of reports, and discussions of topics in the important relevant literature; evaluation, testing, grading, lecturing, discussion section techniques, the term paper, student motivation, theories of learning applied to instruction, student culture, the ethics of teaching, and college teaching as a career. Limited to graduate students teaching in clinical and social sciences in psychology.
Earth and Environmental Sciences

Professors Basu, Ebinger, Mitra, Poreda, Tarduno
Associate Professor Garzoni (Chair)
Assistant Professor Vasili Petrenko
Professors Emeriti Fehn, Lundgren, Sutton

The department offers programs of study leading to a PhD in geosciences and an MS in geological sciences. These programs provide classroom, laboratory, and field instruction as well as research experience to prepare students for successful careers in academia and industry. The department faculty conduct active research in paleomagnetism, seismology, solid earth geochemistry, noble gas geochemistry, cosmogenic isotope geochemistry, light stable isotope geochemistry, environmental geochemistry, geodesy, sedimentary geology, stratigraphy, structural geology, and tectonics. Information on this research can be found at the department’s website: www.ees.rochester.edu.

Graduate research is facilitated by a number of state-of-the-art laboratories that complement active field-based research programs. The department has several mass spectrometers that support research in geochemistry, tectonics and sedimentology. These instruments include a Thermo Electron Delta Plus XP IRMS, a Thermal X57 ICP-MS, and a VG Sector thermal ionization mass spectrometer, used to determine the trace metal content and isotopic composition of geological, environmental, and biological materials. A rare gas mass spectrometer is used for high-precision He, Ne, and Ar isotopic measurements. Sample preparation is undertaken in the department’s cleanlabs, which feature Class 100 air supplies, laminar flow workspaces, and metal-free environments.

Research in paleomagnetism and rock magnetism is carried out in the paleomagnetic laboratory, which features two 2G DC SQUID Superconducting Rock Magnetometers (4.2 cm. and 6 mm bore), a Princeton Measurements 1900 Alternating Gradient Force Magnetometer, and a Geofyzika JR-5A high-speed automatic spinner magnetometer and an AGICO KLY-4 Kappabridge. Data are analyzed using Sun Microsystems UltraSparc workstations.

The active tectonics and geodynamics research laboratory utilizes Unix workstations to analyze, interpret, and simulate seismic, geodetic, and remote sensing data. Broadband seismometers and GPS receivers are used for rapid response to seismic and volcanic events. Longer-term deployments benefit from membership in UNAVCO and IRIS-Pascal equipment pools.

Equipment in the structural geology laboratory includes Olympus and Nikon research microscopes (set up for photomicrography and semi-automated point counting), Leitz microscope and Universal Stage for fabric studies, Technosyn cold-cathode luminoscope, Numonics digitizer, Jandel image analysis system, and IBM PC and Mac computers with various structural and graphics software.

A new ice core laboratory is currently under construction. The laboratory has a walk-in freezer for storing ice core samples from Greenland and Antarctica as well as the world’s largest system for extracting ancient air out of glacial ice. The Ice Core Lab plans to add other systems for processing an analyses of air from glacial ice, including a gas chromatograph for analyses of carbon monoxide and hydrogen, and a laser instrument for analyses of carbon dioxide, car monoxide, and methane; eventually the lab will also house an isotope ratio mass spectrometer.

Graduate students are expected to have a strong background in geoscience and broad knowledge of other sciences and mathematics. However, because of the interdisciplinary nature of research in the department, applications are also welcome from students with strong backgrounds in particular areas of science (especially chemistry, biology, physics, engineering, and materials science) even with only a modest background in geoscience. Financial aid is available in the form of teaching and research assistantships and fellowships. Applications from qualified women and minorities are strongly encouraged.

The department offers a five-year BS/MS program for highly qualified University of Rochester undergraduates. Students should apply to the program early (ideally during the fall of their junior year in order to fulfill all requirements in a timely manner. MS students are expected to spend most of their fifth year in research.

All graduate students are expected to take a combination of courses designed to provide an in-depth understanding of their area of specialization, as well as a general expertise in geological sciences. This curricular program is designed individually for each student, in consultation with the student’s research advisor and thesis committee, and consists primarily of 400-level courses. These courses generally carry four hours of graduate credit each. A limited number of 200- and 300-level courses may be taken for three hours of graduate credit either to make up for a deficiency or to develop a new area of interest. All curricular programs must be approved in advance by the department’s Graduate Studies Coordinator. To ensure that candidates for the MS and PhD obtain experience as teachers, all students are required to aid in instruction for at least one term.

The following courses are regularly offered:

201. Evolution of the Earth
Dynamic history of the earth, its age and evolution, and the origin and evolution of life as revealed by the geologic and fossil record. (Spring)

203. Sedimentology and Stratigraphy
Sediments and sedimentary rocks cover or underlie much of the earth’s surface. In them are recorded both evidence of the processes responsible for shaping the planetary surface and the record of life. Sedimentary rocks contain enormous volumes of water and solid and fluid hydrocarbons, as well as other natural resources. Sediments and sedimentary rocks are very important to our way of life and they are fascinating in themselves. In this course, we describe and classify sedimentary rocks toward understanding the processes that shape them and the environments in which they form.

204. Mineralogy
Lectures discuss the physical and chemical principles governing the properties and formation of minerals. There are three major divisions of the subject matter: (a) geometric and optical
crystallography; (b) crystal chemistry and properties of minerals, and (c) occurrence, origins, and pressure-temperature stabilities of the major rock-forming minerals. Laboratories are devoted to exercises in crystallography, X-ray diffraction, optical mineralogy and hand-specimen mineral identification.

205/405. Solid Earth Geophysics
This course is intended for motivated students who are interested in an introduction to geophysics. Material covered focuses on deep Earth processes: an introduction to potential fields, gravity, heat flow, magnetic fields, propagation of seismic waves and a bottom-up approach to core processes, mantle flow, and plate tectonics.

206/406. Petrology-Geochemistry
Distribution, description, classification, and origin of igneous and metamorphic rocks in the light of theoretical-experimental multicomponent phase equilibria studies; use of trace elements and isotopes as tracers in rock genesis; hand specimen and microscopic examination of the major rock types.

207. Principles of Paleontology
This course is designed to introduce the basic principles of paleontology—the study of fossil organisms in the geological record. Topics covered include taphonomy and the process of fossilization; principles of evolution as evidenced by the fossil record; taxonomy and the recognition and naming of fossil species; biostratigraphy as a means of dating a rock and/or learning about ancient environments; geochemistry of fossils as a means to understand ancient habitats and behaviors. The course includes an overview of important fossil groups with hands-on experience and a field trip.

208. Structural Geology
Geometric analysis of deformed rock, mechanical properties of rock, theories of rock deformation. (Fall)

209/409. Geochemistry
Solar system chemistry, mineralogic, chemical, and isotopic compositions of meteorites; earth’s structure and mineral composition, partial melting, and fractional crystallization models; isotopic heterogeneity of the mantle, and composition of oceanic and continental crust; relative abundances of major sedimentary rocks and mass balance, trace elements in sandstones and limestones, iron formations, element partitioning between river-suspended particles and river water and the adsorption model; distribution, concentration, and speciation of elements in the ocean, marine sediments, manganese nodules, and seamount crusts; and hydrothermal vents of the mid-ocean ridges.

211. Geohazards and Their Mitigation: Living on an Active Planet
Earthquakes and volcanic eruptions are violent manifestations of plate tectonics, the movement of the relatively rigid plates forming earth’s outer shell. Ground moving and shaking from these events may generate tsunamis, slumping and mass wasting, and increase risk in other areas. Global and regional sea level rise changes forces on the plates, motivating reconsideration of hazard assessments. Large volumes of aerosols and greenhouse gases are emitted during volcanic eruptions, with implications for global climate change. The first third of the class focuses on the causative mechanisms of earthquakes, volcanoes, tsunamis, and volcanic-eruption-induced climate change. The second third outlines the consequent hazards and forecasting efforts and feedbacks between these processes. The final third of the course examines mitigation programs, with numerous case studies.

213. Hydrology and Water Resources
This course examines the physical flow of water through the natural environment and its use as a resource for human consumption. The first section of the course looks at the characteristics of water on the Earth: physical and chemical properties, global water balance, and basics of hydrology. The second section concerns understanding and calculating water flows: precipitation, evaporation and evapotranspiration, surface and subsurface runoff, and atmospheric transport. The third section addresses the interaction of humans with water resources: storage in dams, hydropower, municipal usage, agriculture, floods, and water conservation.

215. Environmental and Applied Geophysics
This course aims to image the internal structure of the oceans and continents using geophysical methods. Topics include physical processes occurring within Earth’s plates, including solar and internal energy sources, movement of fluids in the oceans and plates. Geophysical methods used to detect these processes and to constrain physical properties, including seismic, electromagnetic gravity as measured from surface, subsurface, and satellites. Laboratory examples include environmental site remediation, hydrocarbon and mineral exploration, archeological remote sensing, tsunami detection, and groundwater exploration.

216. Environmental Geochemistry
A course in the chemical and physical processes that shape our environment. These include groundwater flow and contaminant mitigation; chemistry of lakes, streams, and the ocean; ocean-atmosphere interactions (ozone depletion); global warming; and the greenhouse effect.

217/417. Physical and Chemical Hydrology
This course provides a foundation in both qualitative and quantitative analyses of the dynamic interaction between water and geologic media. The first part of the course outlines the formation of water, atmospheric processes, and the hydrologic cycle. The second part focuses on the theory and geologic controls on groundwater flow. The third and final part of the course deals with natural groundwater geochemistry and environmental contamination.
218/418. Atmospheric Geochemistry

The atmosphere helps to maintain habitable temperatures on our planet’s surface, shields life from destructive cosmic and ultraviolet radiation, and contains gases such as oxygen and carbon dioxide, which are essential for life. Lectures, discussions, and hands-on activities work toward an understanding of several important questions. How did the Earth acquire an atmosphere? What is in the Earth’s atmosphere? What are the sources and sinks of the most important gases in the atmosphere? What is the role of photochemistry in atmospheric composition?

219. Energy and Society

National and worldwide patterns of energy production and consumption and socioeconomic connections. Environmental effects of extraction, distribution, and consumption; efficiency of resource use; current and projected reserves; socioeconomic and political factors affecting resource utilization; and international trade patterns and energy security.

222. Energy Resources

Examines the mechanisms of oil and natural gas formation: the time, temperature, and pressure conditions. Explores the geochemical and isotopic fingerprints that lead to successful exploitation of hydrocarbon resources. (Spring)

241/441. Igneous-Metamorphic Petrology

Lectures cover an overview of igneous and metamorphic petrology. Origin and distribution of the major igneous-metamorphic rocks in the light of experimental and theoretical multicomponent phase-equilibria studies are the major topics of the lectures. Trace element distribution and isotopes as petrogenetic tracers in the evaluation of the crust-mantle system are also covered in the lectures. Laboratories are devoted to description, identification, and significance of mineral assemblages in these rocks as observed in hand specimens and under the petrographic microscope. (Spring)

248/448. High Temperature Geochemistry

An introduction to the principles of geochemistry. The first portion of the course is devoted to basics, especially thermodynamics and isotope (both stable and radio-) geochemistry. The middle portion of the course deals with high-temperature processes and crystallization. The last part of the course covers low-temperature processes including weathering, sediment diagenesis, and element cycling through the lithosphere. (Spring)

251/451. Introduction to Remote Sensing and Geographic Information Systems

Students learn the basic principles of satellite, airborne, shipborne, and other remote sensing data acquisition systems, and the principles of analyses and interpretation of acquired data sets. Case studies and computer-based practicals focus on visible to near-infrared, thermal, sonar, and radar imaging of Earth’s continents and seafloor and planetary surfaces. Course material includes a review of geographic coordinate systems and projections for georeferencing remotely sensed data as a basis for Geographic Information Systems analyses. Assessment is through computer-based practicals and a short-answer midterm exam.

252/452. Marine Geology

This course provides a comprehensive review of modern marine geology with an emphasis on the deep sea. Areas identified by the Joint Oceanographics Institution as high research priorities are discussed, including new techniques used to study such problems. Four subject areas will be addressed: the lithosphere, tectonics, ocean history, and sedimentary geochemistry and physical processes. (Spring)

253/453. Geodynamics

Processes that create and modify earth and the terrestrial planets will be examined using an “earth engineering” approach. Emphasis is placed on plate tectonics, with discussion of current research in mantle convection. The final third of the course focuses on active plate tectonic boundaries and evidence for plate tectonics on Mars and Venus.

254/454. Geographic Information Systems: Earth Science Applications

This course provides an introduction to Geographic Information Systems, with an emphasis on their application to issues in the earth and environmental sciences. Examples of applications may include land use (and environmental contamination) and its relationship to geology, hydrology, and climate. Other applications (time permitting) include a survey of computer packages routinely used in the marine geoscience community.

255. Planetary Science: Geologic Evolution and Planetary Habitability

EES 255 focuses on geological and geophysical studies of planets (interiors and surfaces) and the conditions that led to the origin of life. The course starts with initial conditions, defined here as the formation of earth and the moon-forming event and trace development of the planet from cooling of the magma ocean onwards. We next consider how our planetary neighbors (Venus and Mars) evolved, as well as key satellites in the solar system that may harbor life, or provide insight into early conditions on earth.

256/456. Paleomagnetism and Global Plate Tectonics

The basic paleomagnetic methods used to determine absolute plate motions are reviewed. Applications include the potential cause and effect relationship between changes in absolute plate motions, mantle plume volcanism, orogeny, and climate change. (Spring)

257/457. Topics in Advanced Seismology

This course examines wave propagation in the Earth and introduces helioseismology. Classes focus on theory of waveform modeling, moment tensor inversions, low-frequency earthquakes, and related topics. Laboratory work focuses on Matlab-based programming.
258/458. Hotspots and Plate Motions
This course provides a basic understanding of hotspot models, hotspot fixity, and the relationships between hotspots, mantle plumes, true polar wander, and plate motions. Hypothesis development and testing are discussed, as well as the basic elements of grantsmanship. (Spring)

259/459. Seminar in Paleomagnetism
Current topics in paleomagnetism and rock magnetism are explored through literature reviews and modeling studies. Topics range from the history of plate tectonics to biogenic magnetism. An introduction to basic concepts in paleomagnetism and rock magnetism is included.

264/264W/464. Paleoenvironmental Reconstructions Using Light-Stable Isotopes
This class focuses on techniques used in environmental reconstructions to address questions related to paleoclimate, paleo-temperature, paleovegetation, and paleo-elevation. Use of stable isotopes in paleoenvironmental reconstructions with particular emphasis on O, C, and to a lesser extent, H and N isotopes is examined. The class starts with a thorough introduction of the geological framework of the environments of interest and the processes of light isotope fractionation. This is followed by “emphasis areas” that highlight the basics and latest developments in a variety of environmental systems, including the oceans, rivers, ice, lakes, soils, and fossils.

265/465. Paleoclimate
The Earth’s climate is changing in a potentially fundamental way because of human activity. This course looks into Earth’s climate history in order to gain a better understanding of how the climate system works and what to expect from Earth’s climate in the future. During its history, the Earth has gone through periods that were much warmer as well as periods that were much colder than today. By examining the geological record of the environmental conditions, insights into key parameters such as greenhouse gas concentrations, insolation, and positions of the continents influence the climate system can be gained.

266/466. Topics in Climate and Environmental Change
This seminar course explores specific topics in the field of climate and environmental change. The seminar delves into the classic as well as most current literature in the selected area. Students get practice with reading and understanding primary scientific literature, scientific discussion and debate, oral presentation of scientific results, as well as scientific writing. Specific topics vary each semester.

269/469. Stable Isotopes in Geochemistry
Application of stable isotope techniques to problems in metamorphic and igneous petrology, hydrothermal alteration, paleo-oceanography, paleoclimatology. (Spring)

270/470. Vertebrate Paleontology
This course covers the fossil record of vertebrate animals. Topics covered include the origin of vertebrates; phylogenetic relationships among modern vertebrates; introductory osteology and comparative anatomy of vertebrates; the advent of bone; the transition to land; the origin of flight in vertebrates; the warm-blooded vs. cold-blooded controversy in dinosaurs; the relationship between birds and dinosaurs; and hominid evolution and the origins of man. Readings from the current scientific literature are used.

283/283W/483. Sedimentary Basin Analysis
By determining how sedimentary basins develop and fill, the tectonic and eustatic controls on subsidence and surficial processes are better understood. Basin classification schemes, flexural and thermal subsidence, isostasy, sequence stratigraphy, and techniques used to characterize sedimentary basin evolution are discussed.

285/285W/485. Structure and Tectonics of Mountain Belts
Orogeny and its relationship to plate tectonics. Structural style and tectonic history of mountain belts with special reference to the Appalachians and Cordilleras. Lectures twice a week. Homework assignments involve drawings and interpreting cross sections through mountain belts. Field trip to the Appalachians to look at typical structures of mountain belts. (Alternate springs)

286/286W/486. Seminar in Sedimentology and Tectonics
Interpreting the lithofacies and chemistry of sedimentary rocks to understand paleoenvironment; impact of tectonics on climate. Topics vary depending on student interest. Course readings, presentations, and discussions of classic and current literature.

288/288W/488. Geometry and Mechanics of Thrust Faults
Geometry of thrust faults and thrust belts. Mechanics of thrust motion and thrust emplacement. Homework assignments and readings on current literature. (Spring)

299. Field Geology
Prerequisite: permission of instructor.

This course covers the essential geologic and geophysical approaches to field stratigraphy, mapping, and structural interpretation. The coursework is based on observations made during a substantial field excursion (usually six weeks long). Additional credit may be earned by laboratory analyses of samples collected during the field excursion.

318W. Environmental Decisions
Prerequisite: permission of instructor.

Lecture and seminar analyzing decisions about some major classes of environmental changes as seen from the viewpoint of scientists and risk analysts. For seniors and graduate students. (Spring)

320/320W. Sustainable Systems
This course examines sustainable systems at multiple scales: an individual building, a university campus, and a metropolitan
community. It combines theoretical discussion with case studies, looking at what issues are the same at each scale and what changes with scale. At the building scale, the focus is on energy, water, and waste. The campus scale analysis broadens to include food, procurement policies, and transportation. The city-wide case study further addresses principles of sustainable urban design. A final project is to develop a practical set of recommendations for a sustainable system, at a scale selected by the student.

360/460. Environmental Geology in the Field and Laboratory
Emphasizes commonly employed methods of obtaining critical geochemical and hydrogeologic data for environmental studies. Visits to drilling sites, geotechnical and analytical labs, and an experimental field station where tests on monitoring wells can be performed. (Fall)

445. Solid Earth Geochemistry
Composition, structure, and evolution of the earth over the past 4.56 billion years; isotopic geochemistry of crust-mantle processes; phase transitions within the earth and their tectonic significance.

446. Neodymium Isotope Geochemistry
This course applies Sm-Nd isotopic methods along with Lu-Hf, Rb-Sr, U-Th-Pb, Re-Os, and the rare earth elements as geochemical tracers to the study of planetary crust-mantle evolutionary processes.

462. Seminar in Noble Gas Geochemistry
This course examines topics in noble gas geochemistry through a series of recent articles on various topics.

467. Isotope Geology
Causes for differences in the isotopic composition of elements. Nucleosynthesis, fractionation, radioactive decay, and cosmogenic production. Evolution of crust and mantle, formation of ore deposits, tracing and fluid movements, history of cosmic ray flux, and other applications of isotopic systems to geologic problems.

480. Material Properties of Deformed Rocks
Elastic, linear, and nonlinear viscous and perfectly plastic behavior of rocks. Effect of dislocation and diffusional creep, grain boundary sliding, microfracturing, and recrystallization on rocks.

481. Microtectonics
Study of microstructures, fabric, and textures in rocks to define deformation patterns, deformation mechanisms, and flow laws.

482. Metamorphic Processes
Metamorphism and its effect on rocks. Pressure-temperature regimes of metamorphism. Tectonic processes related to metamorphism. Case studies from mountain belts.

484. Stress and Strain in Rocks

489. Topics in Advanced Structural Geology
Prerequisite: permission of instructor.
Advanced structural geology course covering topics of current research interest. Topics vary.

490. Supervised College Teaching
Credit—one hour

491. Master’s Readings in Geology

492. Graduate Field Seminar
Credit to be arranged

493. Master’s Essay

495. Master’s Research in Geology
Credit to be arranged

591. PhD Readings in Geology

595. PhD Research in Geology
Credit to be arranged
Economics

Professors Aguiar, Bils (Chair), Engerman, Govindan, Jones, Landsburg, Thomson
Associate Professors Barelli, Chang
Assistant Professors Bai, C. Caetano, G. Caetano, Chen, Hawkins, Hong, Kinsler, Lu, Michaels, Pancs, Pavan, Yildiz
Joint Appointment: Professor Duggan
Senior Lecturer Wolkoff
Lecturer Rizzo
Professor Emeritus Oi

The Department of Economics offers a graduate education that focuses on developing students’ analytical and research capabilities. The blend of coursework, active seminars, research workshops, and informal faculty-student interactions has met with substantial historical success, demonstrated by the professional achievements of the program’s graduates and, more formally, by placement in the top 10 graduate programs, according to the rankings of effectiveness published by the National Academy of Sciences.

The department’s doctoral program requires at least three years of full-time study. The first two years are principally spent in required coursework, with students typically undertaking two or three additional years of on-campus dissertation research. This PhD training builds upon the opportunities for close working relationships between students and faculty that are possible within a small, integrated program. The aspect of the program is especially important during the thesis-writing phase when students confront the frontiers of economic knowledge.

Each student subsequently develops a field of specialization. The available fields are econometrics, economic history, industrial organization, international economics, labor economics, macroeconomics, microeconomic theory, public finance, political economy, and social choice. (For more information about political economy, see W. Allen Wallis Institute of Political Economy.) The student’s preparation is evaluated by a written qualifying examina-
tion in each field of specialization. A distribution requirement, satisfied by taking a graduate course in two fields other than the fields of specialization, insures breadth of knowledge.

All PhD candidates are required to do some supervised teaching as part of the degree requirements. Ordinarily, students will not teach in the first or second year. Advanced students sometimes have the opportunity to teach a course of their own.

Proficiency in both oral and written English is required. The University’s English as a Second Language Program is available for improving English skills. Further details on the graduate program requirements may be found in the departmental memorandum and the Ph.D. Program in Economics: Requirements and Timetable. This and other current and updated information may also be found on the department’s website at www.econ.rochester.edu.

Credit for courses numbered 400–499 is four hours, except as noted; credit for courses numbered 500–599 is five hours, except as noted.

471. Modern Value Theory I
The foundation of modern microeconomic analysis, including consideration of consumer behavior, the theory of the firm, equilibrium under alternative market structures, and welfare implications.

472. Modern Value Theory II
Introduction to general equilibrium analysis, including modern treatment of existence, stability, and comparative statics properties; elements of capital theory.

475. Macroeconomics I
Reviews the main empirical regularities that characterize economic growth and business fluctuations in market economies. Discusses various theoretical models of the business cycle, as well as the macroeconomic impact of fiscal and monetary policy.

476. Macroeconomics II
This course continues with the themes developed in 475: business cycles, economic growth, fiscal and monetary policies. More emphasis is placed on the tools required to do modern macroeconomics: dynamic programming, difference equations, Markov chains, etc. Computational techniques such as linear quadratic and discrete state space dynamic programming, the Coleman algorithm, and parameterized expectations are taught. (No prior knowledge of these techniques is assumed.)

481. Mathematical Economics I
This course covers the use of optimization theory in economic analysis. The topics covered include finite-dimensional optimization (unconstrained optimization, Lagrange’s Theorem, the Kuhn-Tucker Theorem), the role of convexity in optimization, parametric continuity of solutions to optimization problems, and finite- and infinite-horizon dynamic programming.

483. Introduction to Mathematical Statistics
Credit—two hours
Elements of probability theory and statistics, as employed in the econometrics sequence ECO 484–485.

484. Introduction to Econometrics
(Same as APS 514)
Prerequisite: ECO 483 or permission of department.
Credit—two hours
Estimation and hypothesis testing in the standard linear model; small and large sample properties; generalized methods of moments.

485. Elements of Econometrics
(Same as APS 515)
Prerequisite: ECO 484.
491. Reading Course at Master’s Level  
Credit to be arranged

493. Master’s Essay  
Credit—three hours

495. Research at the Master’s Level  
Credit to be arranged

501. Seminar in Labor Economics  
Selected topics in labor economics are discussed. The topics vary from year to year. In recent years, topics have included human capital, models of wage growth, inequality, and labor policy.

502. Topics in Labor Economics  
Selected topics in labor economics are discussed. Second semester of labor economics sequence.

507/508. Economic Theory Workshop  
Topics in economic theory, with papers by faculty and outside speakers. Students are expected to be informed discussants and to present a paper.

509. Seminar in Theory of International Trade  
Theory of specialization according to comparative advantage. Effects of tariffs on the gains from trade and the distribution of income. Standard and new trade theories.

510. International Finance  
Topics in exchange rates, the balance of payments, asset-pricing and international capital flows, macroeconomics of open economies, and monetary systems.

511/512. International Economics Workshop  
Topics in international economics, with papers by faculty and outside speakers. Students are expected to be informed discussants and to present a paper during one semester.

513. Topics in International Trade  
Advanced topics discussed include the theory of trade and growth, the role of trade in middle products, optimality in the theory of international factor mobility, and the relationships among markets in goods, factors, and assets.

514. Topics in International Economics  
This course is an advanced topics course in international economics. The focus is on international risk sharing, current account dynamics and sovereign debt. Emphasis is on small open economy models.

517. Advanced Econometrics  
(Open for APS 523)  
Prerequisite: ECO 485.  
Asymptotic theory for time-series econometrics; generalized method of moments; simulated method of moments; unit root tests; estimation and tests of regime-switching models.

518. Topics in Macroeconometrics  
(Open for APS 524)  
Prerequisite: ECO 517 or permission of instructor.  
Course content varies from year to year. Stationary and nonstationary processes, expectations, unobserved component models, Kalman filtering and volatility are possible topics discussed.

519. Topics in Microeconometrics  
Prerequisite: ECO 517 or permission of instructor.  
Course content varies from year to year. Panel data, cross-section time series, qualitative dependent variables and duration analysis are possible topics discussed.

520. Topics in Econometrics  
This course focuses on recent developments in mathematical statistics and their applications in econometrics. We use the asymptotic theory of decision (LeCam) to systematically derive optimality properties of various parametric tests.

521. Advanced Economic Theory  
This course covers the foundations for the theory of dynamic incentives, applied to repeated games and to repeated moral hazard/incomplete enforcement. We emphasize recursive methods to characterize the set of subgame perfect equilibria of repeated games and optimal contracts in the repeated moral hazard/incomplete enforcement case. Additional topics include renegotiation proofness, Coasian dynamics and time consistency, and extensions of the static principal-agent problem to multiple agents/multiple principals.

522. Topics in Decision Theory  
This course studies choice theory with particular emphasis on choice under risk, the distinction between risk and uncertainty, and behavior in dynamic settings. The approach is largely formal and axiomatic, though applications are also considered.

524. Game Theory  

525. Economic Mechanisms  
Existence and construction of mechanisms with desirable properties, elicitation schemes, implementation of social choice, planning procedures, matching procedures, fair mechanisms, manipulation of mechanisms.
526. Topics in Game Theory
Games with incomplete information, equilibrium refinements, and applications of game theory in industrial organization and other fields.

527. Economic History
Students are expected to present papers evaluating recent research in the field as well as on original topics.

528. Topics in Macroeconomics
First, the course examines economic growth with an emphasis on measurement and the role of human capital. Second, it examines explanations for the relative earnings and employment experience of skilled versus unskilled workers. The final section is devoted to examining the causes of business cycle fluctuations in hours worked.

531/532. Macroeconomics Workshop
Topics in macroeconomics, with papers by faculty and outside speakers. Students are expected to be informed discussants and to present a paper during one semester.

534. Topics in Macroeconomics
Studies dynamic macroeconomic models with heterogeneity in age, income, and wealth across agents. Examines the interplay between macroeconomic variables and inequality. Reviews evidence concerning the models discussed.

535. Quantitative Macroeconomics
This course introduces various computational methods in macroeconomics and its applications. The main topics are (1) learn computational methods, which are extensively used to answer many interesting questions in macroeconomics, and (2) learn how to apply the methods to different interesting issues.

536. Economic Growth
Examines the available empirical evidence on the development process. Discusses theoretical models that highlight the role of capital accumulation, human capital, innovation, technological diffusion, poverty traps, trade and international capital markets, public policy, and population growth.

541. Seminar in the Theory of Public Finance I
Economic theory is used to analyze the economic functions of a government and its associated institutions. Externalities, public goods, and taxes are studied from a general equilibrium perspective. Cost-benefit analysis and expenditures are studied.

542. Seminar in the Theory of Public Finance II
Topics in institutional and empirical public finance at both the national and local levels.

545. Topics in Micro-Development Economics
Topics include labor market efficiency, nutrition-based efficiency wages, peasant household behavior, contractual arrangements, risk and the family, fertility, health, and savings.

551/552. Applied Economics Workshop
Topics in applied economics, with papers by faculty and outside speakers. Students are expected to be informed discussants and to present a paper during one semester.

575. Political Economy I
This course focuses on several foundational topics in theoretical political economy. Within the paradigm of social choice theory, we cover Arrow’s impossibility theorem, the limitations of rational collective decision making, and the consequences for political stability vs. instability. We then take the perspective of noncooperative game theory and cover (among other things), the theory of implementation, strategic voting and the design of nonmanipulable voting rules, and the power of agenda setters.

580. Political Economy I
This course focuses on a variety of theoretical models concerning political and economic behavior, as well as addressing more abstract foundational issues of choice theory and institutional design. Students learn not only about the predicted effects of certain political institutions on economic outcomes, but also about the possibility of (and methods involved in) solving various collective action problems, agency problems, and the like. (Fall)

582. Political Economy II
The course develops and uses theoretical models with economic and political elements. A range of issues is studied with specific applications varying from year to year.

584. Seminar in Industrial Organization
Modern theory of industrial structure and conduct is covered along with empirical studies of its validity. Topics include analysis of pricing, product differentiation, entry and merger. Consequences of concentration and collusion for efficiency and technical progress are examined as well as appropriate policy responses.

591. Reading Course at the PhD Level
Credit to be arranged

595. Research at the PhD Level
Credit to be arranged
The Department of English offers programs of study leading to the degrees PhD or MA.

The program leading to the doctorate emphasizes the critical and scholarly study of English and American literature, as well as cultural studies, critical theory, film, and media studies. It is also concerned with developing the candidate’s ability as a classroom teacher. Candidates may enter the doctoral program directly from their undergraduate work or after completion of the MA. The course of study for the PhD degree begins with two years (60 credits) of coursework for students entering with a BA in English or related fields, and a further year (30 credits) of research and preparation for exams. These courses may include independent readings courses designed by the student in consultation with a member of the faculty and approved by the director of graduate study (DGS). Students entering the program with an MA in English may, subject to approval by the DGS, transfer up to 30 graduate credits and thereby shorten their coursework. PhD students are not ordinarily expected to teach in their first two semesters of study, but are expected to devote full time to their coursework. Students in the PhD program are expected to teach one section of College Writing each semester during years two through four; the candidates’ teaching is supervised by the director of the College Writing Program. Before the end of their second year, PhD students select a faculty committee with whom they work to define and prepare areas of specialization for their qualifying exams. Students take their Language Exams before the end of their second year and the Qualifying Exams before the end of their third year. After completing their exams, students must file a prospectus for their doctoral dissertation.

PhD candidates also must achieve an advanced level of fluency for reading literature and scholarship in at least one foreign language, appropriate to their specialization; some areas of specialization may require more than one foreign language.

The MA program has been set up so that students may finish within a calendar year. MA candidates work out with the DGS a program of 30 credit hours; courses must be at the four-hundred level or above. After finishing coursework, MA students may choose to write an essay or to take a set of comprehensive field examinations; this work is undertaken in consultation with a faculty advisor, whom students generally ask to work with them during the spring semester. There is no foreign language requirement for the MA degree.
554. Cultural Studies

555. Theorizing Documentary

557. Special Literary Problems

558. Video History and Theory

560. Studies in Rhetoric and Literacy

RESEARCH, SUPERVISED TEACHING, AND READING COURSES

571. PhD Supervised Teaching
   Credit—five hours

572. Practicum in Teaching
   Credit—two hours

591. Reading Course at the PhD Level
   Credit to be arranged

595. Research at the PhD Level
   Credit to be arranged

The following courses may be taken for four hours of graduate credit.

400. History of the English Language
   (Same as LIN 435)

401. Old English Literature

402. Middle English Literature

403. Medieval Drama

404. Chaucer

406. Studies in Medieval Literature

407. English Renaissance Literature

408. Renaissance Drama

409. Studies in Shakespeare

410. Shakespeare

411. Milton

413. Studies in Renaissance Literature

414. Eighteenth-Century Literature (1660–1780)

415. Early British Novel

417. Studies in Eighteenth-Century Literature

418. Early American Literature

420. Romantic Literature

421. Victorian Literature

422. Nineteenth-Century British Novel

423. Studies in Nineteenth-Century Literature

425. American Romantics

426. American Realists

427. American Moderns

428. African-American Literature

430. Studies in American Literature

431. The Twentieth-Century British Novel

432. Modern Literature

433. Modern Poetry

434. Modern Fiction

436. Contemporary Fiction

437. Studies in International Literature

438. Studies in Modern and Contemporary Literature

440. Literary Criticism and Theory

441. Lyric Poetry

442. Topics in Literature

443. Studies in a Major Author

444. Studies in a Literary Tradition

445. Studies in a Literary Mode

446. Detective Fiction

447. Science Fiction

448. Studies in Women’s Literature

449. Gender, Writing, and Representation

450. Race in American Fiction
451. Studies in Popular Literature
452. Theater in England
453. Literature of the Bible
454. Arthurian Literature
455. Film History: Early Cinema
456. Film History: 1929–1959
457. Film History: 1959–Present
458. Film Analysis
459. Popular Film Genres
460. Film History
461. Film Theory
462. Studies in a National Cinema
463. The Poetics of Television
464. Studies in a Director
465. Issues in Film
466. Issues in Film Theory
467. Changing Genres of Erotica
468. Museum Studies
469. Museum Practice
470. Curatorial Theory and Practice
471. Film Conservation and Restoration
472. Moving Image Archive Management
473. Laboratory Work
474. Personal Project
475. Advanced Creative Writing: Fiction
476. Advanced Creative Writing: Poetry
478. Advanced Playwriting
480. Seminar
(Same as ENG 380)
Titles vary.
483. Media ABC
484. Orality, Language, and Literacy
485/585. Humanities Research Lab
488. Translation and World Literature
491. Reading Course at the Master’s Level
Credit to be arranged
492. Special Topics
History

The Department of History offers programs of study leading to the degrees of Doctor of Philosophy and Master of Arts. The program leading to the doctorate trains students to be effective teachers and productive scholars in a variety of fields and specialties with a particular emphasis on transnational and comparative history. A detailed description of the graduate program for the doctorate may be obtained on the department’s website www.rochester.edu/College/HIS.

Programs of study are tailored to individual student needs and interest in consultation with the advisor and the director of graduate studies. Doctoral students complete two years of coursework (one and a half years if they enter with an MA). During that span they are required to declare two research and two teaching fields.

Research fields are specialized and concentrated interests that should support dissertation work. Examination for competence consists of summary essays written during the second year. Examples include Intellectual History, African-American migration, Public Health, and similar specialties and concentrations that the faculty offer.

Teaching fields are defined as areas that PhD candidates are prepared to teach as survey courses. Examples include US I & II, Western Civilization, Global History, and so forth. Examination for competence in teaching fields consists of a written exam to be completed in 24 hours and an oral exam taken two weeks later. Teaching fields are examined at the beginning of the third year of study.

 Students are also required to write one paper based on original research during each of the first two years in residence and to take the two-course introductory sequence (HIS 500 and HIS 501). They are also expected to submit and defend a prospectus for the doctoral dissertation and defend the dissertation upon completion. The prospectus defense should take place within three months of passing the written and oral qualifying examinations.

PhD candidates must serve as teaching assistants in the third year of the program and teach their own courses in the fourth or fifth year, depending on the demands of their dissertation research. The duties associated with teaching are considered an integral part of the program and faculty evaluate students during the course of their teaching. Language competence is required as needed.

For information on the MA degree, please see the department’s website: www.rochester.edu/College/HIS.

405. American Health Policy and Politics
This course examines the formation and evolution of American health policy from a political and historical perspective, concentrating primarily on developments from 1932 to the mid-1990s.

406. European Cultural History
This course compares different ways of using novels, plays, paintings, poems, and other forms of artistic expression to improve our understanding of the modern European past.

408. Modernity and Modernism
A study of selected topics in the history of modern thought and culture in Europe and the United States.

410. World War II—Eastern Front
This course covers the history of the Soviet Union’s struggle with Nazi Germany from 1941 to 1945, the largest and bloodiest military conflict in human history.

412. Ancient Greek Historiography
Examines the craft of ancient Greek historiography by looking at the method, style, and purpose of the ancient Greek historians. Included in the historians studied are Herodotus, Thucydides, Xenophon, Polybius, Arrian, Appian and Cassius Dio.

413. The Power of Print
This course examines the history of books, readers, and literacy in the United States from the colonial period to the present. It explores how the printed word shaped both public events (e.g., the Civil War) and private experience (e.g., relationships within the family).

414. International Human Rights
This course, which begins by exploring the history of British, French, and American debates over the ideal extent of human rights, concludes by considering selected case studies from around the contemporary world.

416. Maritime History of the Atlantic World
This course studies European expansion into Africa and the Americas between the ages of Discovery and Revolution by focusing on the Atlantic Ocean as the geographic center of an expansive network of the maritime connections.

418. Nationalism and Ethnic Conflict in Europe, 1800–2000
This course focuses on the history of European nations as political, economic, and cultural entities, and the challenges to these nations posed by migration, political upheaval, various forms of ethnic identification, and ethnic conflict.

422. Richard Wagner and the Nineteenth Century
This course examines Wagner not only as an artist of lasting significance but also as a figure whose art, ideas, and experience...
engaged many of the most important issues of the nineteenth and twentieth centuries, including nationalism, revolution, gender relations, anti-semitism, internationalism, progress, myth-making, and history.

423. Stalinism
Course analyzes Stalinism as a social system, focusing on the 1930s.

428. Victorian England
An interdisciplinary seminar on cultural, intellectual, and political history of nineteenth-century England. Topics include industrial revolution, Liberalism and social reform, religion and science, Victorian colonialism, and origins of the First World War.

430. Russia in East Asia
An advanced seminar for students who are familiar with the outlines of twentieth-century international history in East Asia and Europe. Some knowledge of internal Russian and Soviet history is desirable but not required.

433. America and the World I
Introduces students to the historical literature on the global and transnational context of American history from settlement to the Civil War.

434. America and the World II
Continuation of 433. Covers the historical literature that explores the global and transnational context of American history from the Civil War to the late twentieth century.

435. American Thought
Selected topics in American thought, treating the work of intellectuals in its social, political, and cultural context.

438. Modernity through East Asian Eyes
What is Modernity and what does it mean for China, Japan, and Korea.

440. The Black Family in Slavery and Freedom
This course examines the state of the black family in post–Civil Rights America and proffers some policy proposals for a healthier future for the black family.

442. Emergence of the Modern Congress (Same as PSC 218/518)
Advanced seminar on the history and development of legislative institutions and practices.

443. Race and the American City
This seminar examines the role race has played in defining the physical, cultural, and political environment of American cities in the nineteenth and twentieth centuries.

444. When New York Was the Wild West
This course explores New York’s history from Seneca settlement to Seneca Falls, using recent scholarship to consider Iroquois, Dutch, English, and American periods of history.

445. Just Wars
This seminar considers the concept of just war and the application of just war theory to specific historical cases.

447. The Political Economy of Food in Africa
A three-part exploration of the idea that in the world of African peasants, food does not have an independent life apart from the social relations of those who eat it.

450. Topics in Medieval History
Selected problems in the political, social, and intellectual history of the Middle Ages.

456. The Atlantic Slave Trade and Africa, 1650–1850
This research seminar examines the Atlantic slave trade, with a particular focus on explaining how and why Africa came to occupy the position it did in the Atlantic economic order, which evolved from the sixteenth century to the mid-nineteenth century.

461. Socioeconomic Development in the Atlantic World
This course is a study in Atlantic World history beginning with a comparative examination of the economic, cultural, and political conditions in the major regions of the Atlantic in the mid-fifteenth century.

465. Modern Jewish History
Seminar examines selected significant topics in modern Jewish history in Europe, the Ottoman Empire/Middle East, and the United States, from the mid-seventeenth century through the twentieth.

473. Sex and Gender in the American City
This course explores the role of gender and sexuality in American cities from the nineteenth century to the present.

482. Topics in the Twentieth-Century American Cultural History
Research seminar on selected topics in modern American cultural history, emphasizing recent scholarship.

484. Urban Change and City Politics (Same as PSC 241/530)
Examines major issues in the study of city politics, with an emphasis on the American city, present and past.

487. Nation and Culture in Twentieth-Century China
This course focuses on the evolution and expression of Chinese nationalism from the fall of the Qing dynasty (1911) through the Second World War and Communist Revolution (1949).
489. Gender in Late Imperial and Modern China
This course examines problems in the interpretation of gender in the non-Western world with China as the primary historical example. It focuses on the understanding and deployment of gender under a succession of regimes in Chinese history: the Confucian/imperial order, missionary reformism, elite modernization, and state socialism.

491. Directed Readings at the Master’s Level
Individual, specialized reading courses; topics, relevant to student's program, chosen in consultation with faculty member.

495. Research at the Master’s Level
Credit—to be arranged

496. Extended Studies at the Master’s Level
Credit—to be arranged
Extended reading or research in history at the master’s level.

500. Problems in Historical Analysis
Explores the debates about what historians do and how they do it. Investigates the status of historical truth, diverse methodologies, and the function and purpose of historical work.

501. Topics in Historical Interpretation and Explanation
Acquaints students with the different forms and types of history with a particular emphasis on the worlds of inquiry that characterize Rochester historians. Units on nations, goods, and knowledge.

511. Advanced Historical Studies
Credit—one hour
Investigation of selected topics in history.

512. Advanced Historical Studies
Credit—two hours
Investigation of selected topics in history.

513. Advanced Historical Studies
Credit—three hours
Investigation of selected topics in history.

590. Supervised Teaching in History
Credit—none
Individual instruction in the teaching of history under the supervision of a faculty member. For first-year PhD students.

591. Directed Readings at the PhD Level
Individual, specialized reading courses; topics, directly relevant to student's program, chosen in consultation with faculty member.

592. Independent Readings at the PhD Level
Individual readings course pursued independently in consultation with faculty member; topics relevant to student's program.

593. Assisting in History
Experience, under faculty supervision, in conducting discussion sections and examinations in undergraduate history courses.

595. Research at the PhD Level
Credit—to be arranged

596. Extended Studies at the PhD Level
Credit—to be arranged
Extended reading or research in history at the PhD level.
Linguistics

Professor Carlson
Associate Professors McDonough (Chair), Runner
Assistant Professors Gunlogson, Pauw
Instructor Silva
Professors Emeriti Moutsos, Sapon

The Department of Linguistics offers an MA in linguistics, and participates in programs offering interdisciplinary joint PhD degrees in the cognitive sciences in conjunction with the Departments of Computer Science, Philosophy, and Brain and Cognitive Sciences. For more information, contact the Department of Linguistics.

Master’s Degrees

Requirements for the MA in Linguistics

The Department of Linguistics at the University of Rochester offers graduate training in linguistics leading to the Master of Arts (MA) degree. The emphasis for the master’s program is to prepare students for further work at the PhD level in linguistics or another related field or in industry through the pursuit of independent research. The department offers the following orientation:

1. Familiarity with contemporary linguistic studies in the generative tradition.
2. Empirical, data-oriented program.
3. Exploration of the relationship between theoretical linguistics and other fields of cognitive science.
4. Preparation for the teaching profession.
5. It is also possible to integrate the study of linguistics into PhD programs offered through the Departments of Computer Science, Philosophy, and Brain and Cognitive Sciences. To do this, candidates must apply directly to those departments for admission.

Admission

All applicants are required to submit the following materials along with the application: transcripts; GRE scores; three letters of recommendation. In addition, it is strongly recommended that all applicants submit a sample of written work (e.g., a copy of a term paper, senior thesis, master’s essay, etc.). This writing sample need not deal with linguistics, as long as it demonstrates the applicant’s scholarly ability. A background in linguistics is desirable but not necessary. If the work is in a language other than English, a summary in English should be attached.

Those applicants whose native language is other than English are required to submit TOEFL scores as well. Supporting documents by February 1 to the Department of Linguistics, 503 Lattimore Hall, University of Rochester, P.O. Box 270096, Rochester, NY 14627-0096.

405. Historical Linguistics

This course is designed to give an introduction to the principles of historical linguistics and their practical application. Topics covered include genetic relations; sound change; borrowing; the comparative method and language classification; types of language contact; morphological, syntactic, and semantic change; and areal linguistics.

408. Language Development Acquisition

(Same as BCS 555)

Covers a broad range of topics on the child’s acquisition of a native language, including literature on the acquisition of spoken and signed languages, as well as theories of the language learning process. Focus is on the acquisition of syntax and morphology.

410. Introduction to Language Sound Systems

Orients students to the principles underlying sound systems in human language. Practice in the production, recognition, and transcription of sounds in various languages of the world, and to the fundamentals of phonological analysis and argumentation through hands-on investigation of language sound systems. Focus in the course is an illustration and documentation of the sound system of a language with data collected from a native speaker in a language of the student’s choice. No background in phonology or phonetics is assumed.

419. Philosophy of Language

(Same as PHL 447)

A study of the philosophical questions about language and the general nature of language.

420. Introduction to Grammatical Systems

This introductory course examines the grammatical structure of sentences from the standpoint of modern linguistic theory. The course develops the basic techniques and concepts of syntactic analysis placing particular emphasis on the ways in which semantic, morphological, and lexical information interacts with the syntax. No syntax background is assumed. This course is intended for majors and non-majors alike.

425. Introduction to Semantic Analysis

This course introduces students to the basic logical notation and techniques used in formal analysis of natural language meaning, primarily in terms of truth-conditions. The course covers the basics of first-order logic and set theory and begins to investigate how meanings represented in these terms correlate with the syntactic and lexical structures of sentences of natural language. Topics include such notions as negation, conjunction and disjunction, plurality, quantification, indexicality, entailment, implicature, and presupposition. Students of graduate standing or those with strong formal backgrounds should consider starting with LIN 265/465 instead, for which this course is ordinarily a prerequisite.

* Primary appointment in another department
426. Morphology
The course examines the structure and definition of the linguistic unit “word,” its typology, and the relationship of the morphological component to other levels in the grammar. The course includes an introduction to analytical techniques with emphasis placed on an examination of data from a range of languages. The building blocks of words are analyzed and topics such as affixation, reduplication, and inflectional and derivational morphology are covered. Also covered are the properties of words and how they fit into the larger structure of linguistic knowledge, including the relationship between words and syntactic structure (ex. phrases and sentences) and the relationship between words and phonological structure (ex. phonological rules and prosodic structure).

427. Topics in Phonetics and Phonology
This course picks up where LIN 420 leaves off, examining research issues in phonetics and phonology. Topics may include speech production and perception, tone and intonation, or rhythm and meter within a broadly defined laboratory phonology approach. The goal of this course is to familiarize students with current issues on a given topic through readings and discussion and to design and run an experiment or research project on the semester’s topic.

434. Modern English Grammar
Modern English Grammar is a systematic and rigorous survey of the structure of contemporary, general purpose, international Standard English. The course surveys principles governing the construction of English words, phrases, clauses, and sentences, and examines elements of the English spelling system. Throughout, the course pays attention to areas of grammar that commonly come to the attention of writers and learners, with a focus on how an understanding of the systematic nature of the language might yield insight into these and other phenomena.

435. History of the English Language
(Same as ENG 400)
English sounds, inflections, syntax, and vocabulary emphasizing the structure of present-day English.

447. Natural Language Processing
(Same as CSC 247, but requiring a significant project for graduate students)
Prerequisite: CSC 206, CSC 440, or permission of instructor.
Introductory survey of problems involved in constructing computer programs which “understand” natural language and the methods that have been developed to overcome these problems. Solutions to be illustrated by examination of existing computer systems for natural language understanding.

448. Speech Recognition and Statistical Language Processing
(Same as CSC 448, BCS 533)
An introduction to statistical natural language processing and automatic speech recognition techniques. This course presents the theory and practice behind the recently developed language processing technologies that enable applications such as speech-driven dictation systems, document search engines (e.g., finding Web pages), and automatic machine translation.

460. Syntactic Theory
This course picks up where LIN 220/420 leaves off, exploring topics in natural language syntax from a cross-linguistic perspective. The goal of the course is a theory of syntax that accounts for both language-particular as well as universal constraints on language. The orientation is transformational, though lexical perspectives are also explored. Among the topics to be studied are phrase structure, constraints on coreference (binding), the syntactic roles of case, agreement and inflection, thematic roles, long- and short-distance dependencies (extraction and NP movement), constraints on unexpressed phrases (trace and control theory), and quantifier scope.

461. Phrase Structure Grammars
This course picks up where LIN 220/420 leaves off, exploring topics in natural language syntax. The orientation is lexicalist, developing grammatical analyses using Head-driven Phrase Structure Grammar (HSPG) approach, though transformational perspectives are also discussed as points of comparison. By the end of this course, students are able to provide detailed syntactic analyses for highly complex sentences of English; in addition, they acquire the tools to probe the syntactic structures of sentences from any human language.

462. Topics in Experimental Syntax
This course provides an introduction to experimental methods that can be used to investigate questions that are relevant for syntactic theory. The course covers a range of methodologies, including self-paced reading, visual world eye-tracking, magnitude estimation, and questionnaires. During the class, students learn to understand and critically evaluate research that uses various experimental methods and to design and run their own experiments.

465. Formal Semantics
This course is an in-depth introduction to the formal analysis of natural language meaning, employing techniques that have been developed in language and formal philosophy over the last century. Issues include intensionality, quantification, tense, presupposition, plurality, the analysis of discourse, and other current issues. Familiarity with syntax, logic, and/or computation is helpful but not necessary.

466. Pragmatics
Within theoretical linguistics, pragmatics is (broadly speaking) the study of how language users convey meaning. The concerns of this course fall into three general areas: (1) how meaning carried by linguistic elements (such as sentences) interacts with meaning arising from inferences about speakers’ intentions; (2) ways of characterizing meaning, especially with respect to linguistic elements not easily handled in traditional semantic (i.e., truth-conditional) terms; (3) the role of context.
in determining meaning. Topics discussed include the relation between semantics and pragmatics; representations of context; truth-conditional and other types of meaning; presupposition; implicature and Grice’s Cooperative Principle; anaphora; information structure; speech acts. Emphasis is on developing formal methods and analyses.

467. Topics in Syntax and Semantics
This course examines issues at the interface of syntax and semantics with a concentration on the syntax and semantics of Logical Form (LF). There is a focus on both the developments of LF as a level of representation for the analysis of quantifiers and its current role as an important part of the analysis of language variation within the Principles and Parameters framework. No background in semantics is needed, though some basic syntax (e.g., LIN 420) is assumed.

469. Sign Language Psycholinguistics and Acquisition
(Same as BCS 569)
Consideration of the processing, historical development, and acquisition of signed languages, with an interest in the ways that language processing, development, and evolution may affect language structure.

491. Reading Course at the MA Level
Prerequisite: permission of department.
Credit to be arranged

495. Research at the MA Level
Prerequisite: permission of department.
Credit to be arranged

501. Methods in Linguistic Research (pending school approval)
An introduction to the field of linguistics and natural language emphasizing a theoretical perspective. Topics cover subfields of linguistics, including phonetics, phonology, morphology, syntax, semantics, and pragmatics.

520. Syntax (pending school approval)
This is a graduate class on syntactic theory, focusing mainly on modern formal approaches to cross-linguistic language structure phenomena. In addition to reading original research leading up to the current state of the art, the course focuses on several case studies (such as pronoun/reflexive reference resolution and ellipsis phenomena) comparing transformational and lexicalist approaches.

525. Graduate Semantics (pending school approval)
This course examines a current issue in semantic theory, within the context of a broader theoretical approach to how natural languages meanings are to be analyzed.

527. Topics in Phonetics and Phonology
This seminar focuses on selected topics in phonetic and phonological theory. Past topics include prosody and intonation. For graduate students, postdocs, and faculty in the language sciences.

535. Formal Pragmatics
Pragmatics, under one conception, is the study of systematic relationships between what linguistic expressions mean and what people mean when they utter such expressions in a particular place, at a particular time, to a particular audience. This course provides an overview of selected topics in the field, including indexicality, Grice and implicature, speech acts and sentence type, information structure, presupposition, and experimental pragmatics. The emphasis on formal pragmatics means that wherever possible, concentration is on theoretical approaches that attempt to model pragmatic effects in a rigorous way, using methods adopted from formal semantics and neighboring fields.

566. Topics in Understanding Language
This seminar focuses on selected topics in language processing. For graduate students and faculty in the language sciences. The specific topic for a particular year will be announced.

591. Reading Course at the PhD Level
Prerequisite: permission of department.
Credit to be arranged

595. Research at the PhD Level
Prerequisite: permission of department.
Credit to be arranged
Mathematics

Professors Cohen, Gage, Gonek, Greenleaf (Chair), Harper, Iosevich, Lubkin, Mueller, Ravenel
Associate Professors Geba, Jochnowitz, Pakianathan, Salur, Tucker
Assistant Professors Haessig, Starr
Joint Appointments: Professors Clark, Rajeev, Shapiro
Professors Emeriti Alling, Gitler, Lavine, Neisendorfer, Pizer, Prill, Raimi, Stein, D. Stone

The Department of Mathematics offers the Master of Arts (Plan B), Master of Science in applied mathematics, and Doctor of Philosophy degrees. Applicants are normally assumed to have the equivalent of an undergraduate major in mathematics. This usually includes a year of abstract algebra and a year of real and/or complex analysis.

The MA requires 30 hours of coursework, including MTH 436, 440, 467, 471, or their equivalent. The candidate must also pass an examination based on the courses presented for the degree. The joint MA in mathematics and statistics requires 36 credit hours. (Contact the department for the description and program of study.) Joint MAs with other departments may be arranged on an individual basis.

The MS in applied mathematics requires the following core of mathematical courses: MTH 467, 471. All students enrolled in this program will be required to demonstrate proficiency in a high-level computer language. Students will be able to choose between two options, Plan A or Plan B. Additional credit hours will normally be chosen from graduate courses in mathematics or related technical fields.

The PhD requires two years of full-time study, including at least five formal courses at the 500 level, plus preliminary and qualifying examinations and a dissertation. The PhD requires a total of 90 credit hours. Approximately eight 500-level courses are offered each year. The written portion of the qualifying examination covers MTH 436, 437, 440, 453, 467, and 471. The oral portion is devoted to assigned reading from the research literature.

At least three years of supervised college teaching (MTH 590) are required for all candidates. Candidates may be excused from part or all of this requirement on the basis of previous teaching experience. Research for the doctoral dissertation usually consumes at least one year.

Foreign students are encouraged to consider the University’s English as a Second Language Program, as adequate proficiency in English is necessary for employment as a teaching assistant.

Students may take the upper-level undergraduate courses (numbered in the 200s or 300s) for credit. Each such course carries three credit hours, but MTH 235, 236, and 255 do not carry credit toward a graduate degree in mathematics. See the Official Bulletin: Undergraduate Studies or the Web site (www.math.rochester.edu) for a listing of undergraduate courses.

All 400-level courses except MTH 463 are offered every year.

436. Algebra I
Prerequisite: MTH 237 or equivalent.
Rings and modules, group theory. Galois theory.

437. Algebra II
Prerequisite: MTH 436.
Multilinear algebra, quadratic forms, simple and semi-simple rings and modules.

440. General Topology
Prerequisite: MTH 265 or equivalent.

443. Algebraic Topology I
Prerequisites: MTH 436 and 440.
The combinatorial structure of complexes and the homology of polyhedra. Application of algebraic techniques in topology to classification of surfaces, fixed point theory, and analysis.

453. Differentiable Manifolds
Prerequisites: MTH 237 and 440.
Differentiable manifolds, mappings and embeddings, exterior differential forms, affine connections, curvature and torsion, Riemannian geometry, introduction to Lie groups and Lie Algebras.

463. Differential Equations
Prerequisite: MTH 472.
Studies the main tools and classes of PDEs.

467. Theory of Analytic Functions I
Prerequisite: MTH 265 or equivalent.
Cauchy theorems, Taylor and Laurent series, residues, conformal mapping, analytic continuation, product theorems.

471. Real Analysis
Prerequisite: MTH 265 or equivalent.

472. Functional Analysis I
Prerequisite: MTH 471.
491. Reading Course at the Master's Level
Prerequisite: permission of department.
Credit to be arranged
Special work for master's degree candidates, arranged individually.
About eight 500-level courses are offered each year depending on the interests of students and faculty. The following list represents courses offered in the past several years by members of the present faculty. Each course carries four hours of credit, or as noted.

503. Theory of Probability
(Same as STT 503)
Prerequisite: MTH 471.
Characteristic functions. The central limit theorem. Infinitely divisible laws. Random walk on groups.

504. Stochastic Processes
(Same as STT 504)
Prerequisite: MTH 471.

505. Topics in Diffusion

506. Advanced Topics in Probability Theory
Topics are related to recent research in the field.

515. Financial Mathematics
The course takes a mathematical approach to pricing options and other derivatives. It presents a self-contained introduction to stochastic calculus including Ito's formula and the Cameron-Martin-Girsanov formula. One of the principal applications is the Black-Scholes formula. A general approach to pricing derivatives is also considered.

523. Singularities
Prerequisite: basic ideas in homology/cohomology.
An introduction of some of the basic topological and analytic geometric ideas in the local study of singularities of complex varieties, especially hypersurfaces.

530. Elliptic Curves and Elliptic L-Series
Study of elliptic curves and elliptic L-series.

531. Topics in Algebraic Number Theory
Valuations, ideal theory, divisors. Class number, unit theorem. Geometric applications.
544. Homotopy Theory  
**Prerequisite:** MTH 543.
The basic theory through the Hurewicz and Whitehead theory. Detailed discussion of algebraic 2-types based on paper of Eilenberg-MacLane and MacLane-Whitehead. If time permits, the Eilenberg-Whitehead formulation of obstruction theory will be developed and application made.

545. Characteristic Classes  
**Prerequisite:** knowledge of cohomology theory.
Vector bundles, characteristic classes, cobordism.

546. Cohomology

548. Lie Groups and Lie Algebras II
Structure theory of finite dimensional Lie algebras, root-weight systems, Dynkin diagrams, classification of semisimple Lie algebras over C, representation theory of Lie groups and Lie algebras, cohomology of Lie algebras and Lie groups and applications. If time permits, further topics include p-adic Lie algebras and pro-p groups, finite simple groups of Lie type and knot invariants of Lie type.

549. Topics in Algebraic Topology
Introduction to research in algebraic topology; course covers: cup products, fibrations, spectral sequences, and cohomology operations with particular attention to Eilenberg-MacLane spaces.

550. Topics in Topology
Topics are related to recent research in the field.

551. Riemann Surfaces
Definition of Riemann surfaces and the many ways from which they arise. Compact Riemann surfaces, elliptic and hyperelliptic cases; functions and differentials; divisors, special divisors, the Riemann-Roch, Abel, and Jacobi inversion theorems.

552. Integral Geometry
Topics from “classical” integral geometry with applications to geometric inequalities (measures for sets of lines, planes, hyperplanes, in R2, R3, and Rn); measures for geodesics; kinematic measure, Crofton formulae, Blaschke formulae.

553. Differentiable Manifolds  
**Prerequisites:** MTH 237 and 440.
Differentiable manifolds, mappings and embeddings, exterior differential forms, affine connections, curvature and torsion, Riemannian geometry, introduction to Lie groups and Lie algebras.

555. Topics in Advanced Differential Geometry and Applications I
Moving frames, connections, bundles; Gauss-Bonnet theorem and generalizations; theorems of Chern-Lashof; geodesics, Jacobi fields, index theorems.

556. Advanced Differential Geometry and Applications II
First and second variation of minimal surfaces; rigidity; comparison theorems; calculus of variations in the large.

557. Topics in Differential Geometry
Subject matter to be selected from among advanced topics of current interest in differential geometry and geometric analysis.

562. Fourier Series  
**Prerequisite:** MTH 471.

564. Theory of Distributions  
**Prerequisites:** MTH 436, 467, 471, and permission of instructor.
The theory of distributions of Laurent Schwartz in n-dimensional space. Fourier transform. Applications.

565. Topics in Partial Differential Equations  
**Prerequisite:** MTH 564.
Linear partial differential operators with constant coefficients. Elementary solutions. Elliptic, hypo-elliptic, and hyperbolic operators.

566. Lie Transformation Groups, Geometry, and Global Analysis

567. Theory of Analytic Functions  
**Prerequisite:** MTH 467.
Entire and meromorphic functions, Picard's theorem, normal families, Riemann and Osgood-Caratheodory conformal mapping theorems, harmonic functions, univalent functions, Nevanlinna theory.

568. Topics in Number Theory  
**Prerequisite:** none.
This course starts with the definitions and introductory theory of modular forms, presents an overview of some of the classic papers on the subject, and focuses in on some of the recent advances. Particular topics chosen each year are left up to the individual instructor.
569. Topics in Analytic Number Theory  
Prerequisites: MTH 467 and 230 or equivalent.  
Selected topics in non-multiplicative analytic number theory 
considered on a seminar basis.

570. Hilbert Space  
Prerequisites: MTH 440 and 471.  
Unitary, symmetric, and self-adjoint operators, spectral theorem, 
functions of operators, eigenvalue problems.

571. Analysis on Manifolds  
The goal of this course is to present the basic tools necessary 
to talk about differential and pseudodifferential operators on 
manifolds. Discussion of the Atiyak-Singer theorem; includes 
complete proof of theorem that elliptic pseudodifferential 
operators are Fredholm.

573. Pseudodifferential Operators and Fourier Integral Operators  
Prerequisite: familiarity with the Fourier transform and theory of distributions. Some knowledge of partial differential equations is helpful.  
Pseudodifferential operators: symbol classes, adjoints and com-
positions, boundedness on Sobolev spaces, elliptic regularity and 
uniqueness for the Cauchy problem. Fourier integral operators: 
phase functions, symplectic geometry, composition calculus, 
Egorov’s Theorem, propagation of singularities for operators of 
real principal type. Normal forms, Weyl’s Theorem.

574. Group Representations  
Prerequisite: MTH 570.  
The representation of topological groups by unitary operators on 
Hilbert space; classification, decomposition theory, induced rep-
resentations, duality, group algebras, projective representations.

577. An Introduction to Wavelets  
Continuous wavelets transform, windowed Fourier transform, 
frames, time-frequency density, multi-resolution analysis, or-tho-
normal wavelet bases. Applications.

578. Topics in Harmonic Analysis  
A survey of modern Fourier analysis. Summability of Fourier 
series and transforms. Restriction theorems for the Fourier trans-
form. Estimates for oscillatory integrals and oscillatory integral 
opertators. Combinatorial techniques.

579. Topics in Linear PDE  
Methods of microlocal analysis. Applications to local solvability 
and propagation of singularities. Weyl’s law and spectral asym-
ptotics. Boundary value problems.

585. Topics in Mathematical Physics  
Possible topics include unbounded operators and their spectral theory, 
quantum mechanics and its mathematical problems, scattering theory.

588. Scattering Theory  
Classical particle scattering. Quantum scattering: time-
dependent theory, time-independent methods, eigenfunction 
expansions, properties of the S-matrix. Some knowledge of 
Hilbert space helpful, but not necessary.

589. Topics in Inverse Problems  
Discussion of the solution of the inverse conductivity problem of 
Calderon. Fixed frequency inverse scattering, and n-dimensional 
Borg-Levinson theorem, the anisotropic problem in two dimen-
sions using isothermal coordinates. Time permitting, we discuss 
inverse problems for some nonlinear equations, survey of results 
for obstacle scattering, and the wave equation.

590. Supervised College Teaching  
Credit—none  
One classroom hour per week of discussion and problem solving 
with a small group of University of Rochester students, under 
the guidance of a member of the faculty.

591. Reading Course at the PhD Level  
Prerequisite: permission of department.  
Credit to be arranged  
Special work for doctoral candidates, arranged individually.

595. Research at the PhD Level  
Credit to be arranged.

597. Seminar  
Prerequisite: permission of department.  
Credit to be arranged  
For doctoral candidates; topics to be selected.

599. Mathematics Colloquium  
Credit—none  
Weekly lectures by invited speakers on topics of current inter-
rest in mathematical research. Required of all students who have 
completed one year of graduate study.
Philosophy

Professors Conee, Curren (Chair), Feldman, Meerbote, Modrak
Associate Professors Dees, FitzPatrick, Ney
Assistant Professor Weslake
Senior Lecturer Bennett
Joint Appointments: Professors Carlson, Wierenga
Professors Emeriti Eberle, Holmes, O’Brien

The Department of Philosophy offers programs of study leading to the degrees of Doctor of Philosophy and Master of Arts. The programs emphasize ethics, epistemology, metaphysics, philosophy of science, history of philosophy, and logic. The program leading to the doctorate emphasizes training for scholarly research and teaching. The department cooperates with the Departments of Computer Science, Brain and Cognitive Sciences, and Linguistics in a graduate program in cognitive science. A detailed description of these programs may be obtained upon request from the department.

Prior to starting work on a dissertation, all candidates for the PhD are required to complete the foundations requirement and the concentration requirement. The foundations requirement, to be completed by the end of the third semester, requires nine graduate level courses, including one in logic, one in the history of modern philosophy, and one in the history of Ancient Greek Philosophy. The concentration requirement includes six advanced courses followed by a comprehensive exam in each of a student’s two concentration areas. All students are required to take one semester of PHL 581 and most spend several semesters as a teaching assistant.

When a student has completed all of these requirements, he or she may petition the department to conduct the qualifying examination.

The MA degree is awarded upon completion of six graduate courses and a master’s essay (Plan A) or completion of eight graduate courses and one comprehensive examination (Plan B). Both part-time and full-time students may be admitted. Both plans require courses in logic and history of philosophy. MA students are not required to serve as teaching assistants.

All courses carry four credit hours unless otherwise noted.

414. Logical Methods in Philosophy
Prerequisite: PHL 110 or equivalent.
Introduction to formal syntax and semantics, applied to modal logic, tense logic, free logic, subjunctive conditionals; elementary introduction to set theory.

415. Intermediate Logic
Prerequisite: PHL 110 or equivalent.

416. Mathematical Logic
Prerequisite: PHL 110 or equivalent.
Computability, incompleteness of arithmetic, metatheory of propositional and predicate logic.

417. Uncertain Inference
(Same as CSC 417)
Prerequisite: PHL 110 or equivalent.
The exploration of various measures of uncertainty proposed in both philosophy and computer science.

418. Philosophy of Mathematics
Prerequisite: PHL 110 or equivalent.
A study of the nature of mathematics from a philosophical point of view.

419. Deviant Logic
Prerequisite: PHL 110 or equivalent.
The study of “alternative” logics: logics in which more than two truth values are possible, logics designed to accommodate vagueness, logics that allow inconsistencies.

420. Recent Ethical Theory
Prerequisite: PHL 102 or permission of instructor.
An examination of the main twentieth-century ethical and metaethical theories.

421. Philosophical Foundations of the American Revolution
Prerequisite: one previous course in philosophy or permission of instructor.
An examination of the political theory which lies behind the Revolution itself and which underlies the foundations of the Constitution.

422. Social and Political Philosophy
Prerequisite: PHL 102 or permission of instructor.
An inquiry into the nature of human society, the role of the state, and relation of moral to legal obligations.

424. History of Ethics
Prerequisite: one previous course in philosophy.
An examination of the major writers on ethics in Western thought, including Plato, Aristotle, Aurelius, Augustine, Hume, Kant, Mill, and Nietzsche.

426. Philosophy of Law
Prerequisite: one previous course in philosophy.
The nature of law and legal practice in relation to ethics.

428. Public Health Ethics
Prerequisite: one previous course in philosophy.
This course examines the values of health, social needs, and freedom through a systematic examination of situations in which these conflicts arise.
429. Philosophy of Education  
*Prerequisite: one previous course in philosophy.*
Addresses a variety of philosophical and policy debates about education, using selections from philosophical classics and contemporary readings.

430. Environmental Justice  
*Prerequisite: one previous course in philosophy.*
Considers environmental problems and the distribution of environmental resources and burdens from the standpoint of ethics and political philosophy.

442. Metaphysics  
*Prerequisite: one previous course in philosophy.*
A survey of a few recent metaphysical controversies, concerning topics such as free will, the nature of mental states, the existence of universals, and personal identity.

443. Theory of Knowledge  
*Prerequisite: one previous course in philosophy.*
Nature and extent of human knowledge. What is knowledge? Can skepticism be refuted? Under what conditions are beliefs justified or rational? Can anyone know what is right and wrong?

444. Philosophy of Mind  
*Prerequisite: one previous course in philosophy.*
A discussion of the nature of mind and mental states.

447. Philosophy of Language  
*Prerequisite: one previous course in philosophy.*
A study of philosophical questions about language and the general nature of language.

449. Formal Semantics  
*Prerequisite: one previous course in philosophy.*
An in-depth introduction to the formal analysis of natural language meaning, employing techniques that have been developed in language and formal philosophy over the last century.

451. Philosophy of Biology  
*Prerequisite: PHL 110 or permission of instructor.*
An introduction to philosophy of biology focusing on issues connected with the nature and scope of biological explanations.

452. Philosophy of Science  
*Prerequisite: PHL 110 or permission of instructor.*
An examination of scientific theories, nature of causal and statistical explanation.

454. Philosophy of Cognitive Science  
*Prerequisite: PHL 110 or permission of instructor.*
This course is an introduction to the philosophy of cognitive science. Possible topics include the structure of cognition; theories of mental representation; explanation and reduction in cognitive science; folk psychology and theory of mind; and evolutionary psychology.

460. Contemporary Issues in Philosophical Theology  
A philosophical examination of such theological concepts as original sin, atonement, incarnation, and trinity.

461. Kant  
*Prerequisite: PHL 202.*
A study of the philosophy of Immanuel Kant focusing on the Critique of Pure Reason. The course also pays some attention to several issues in Kant's practical and moral philosophy such as his account of volition and the free-will problem.

465. Selected Topics in Ancient Greek Philosophy  
*Prerequisite: PHL 201 or permission of instructor.*
A topical approach to the study of philosophy of the Presocratics, Plato, Aristotle, Epicurus, the Stoics, and the Hellenistic skeptics.

466. Rationalism  
*Prerequisite: PHL 202.*
The study of three great philosophical figures of the rationalist period: Descartes, Leibniz, and Spinoza, with emphasis on the latter. Topics include the nature of substance, of space and time, and of knowledge and mind.

467. British Empiricism  
*Prerequisite: PHL 202.*
Studies in the philosophy of Locke, Hume, and Reid. Topics include theories of knowledge, consciousness, space, and perception.

468. Augustine, Anselm, and Aquinas  
Critical examination of the writings of these important philosophers/theologians, with particular attention to their views that are relevant to the philosophy of religion.

469. The Origins of Analytic Philosophy  
A study of the origins and development of the analytic tradition in philosophy through the writings of Frege, Russell, and the early Wittgenstein. The focus of the course is on their views on logic, language, mathematics, and the nature of philosophy.

491. Reading Course at the Master’s Level  
*Credit to be arranged*  
Reading and analysis of philosophical literature by individual students in consultation with members of the staff.

493. Master’s Essay  
*Credit—three hours*
495. Research at the Master’s Level  
*Credit—6 to 12 hours*

502. Selected Topics in the Theory of Knowledge

503. Selected Topics in History of Philosophy I

504. Selected Topics in History of Philosophy II

505. Semantics

506. Selected Topics in Logical Theory

507. British Empiricism

508. Probability and Induction

509. Decision Theory

510. Selected Topics in the Theory of Value

514. Selected Topics in Ancient Philosophy

515. Selected Topics in the Philosophy of Mind

516. Selected Topics in the Philosophy of Language

517. Selected Topics in Ethics

518. Selected Topics in Moral Philosophy

519. Selected Topics in History of Modern Philosophy

520. Selected Topics in Political Philosophy

521. Aristotle

522. Plato

526. Theories of Justice

527. Berkeley

529. Rationalism and Empiricism

530. Kant I

531. Kant II

541. Aesthetics

542. Selected Topics in Metaphysics

552. Selected Topics in History and Philosophy of Science

560. Writing Seminar

Study of recent articles; writing short commentaries, replies, criticisms. Covers various topics under guidance of several faculty members.

565. Selected Topics in the Philosophy of Religion

571. Philosophy of Cognitive Science

580. Supervised Instruction in Philosophy

Supervised teaching of undergraduates, including leading discussion sections, grading tests and papers, and meeting with students.

581. Supervised Instruction in Philosophy

Continuation of PHL 580, with practice lecturing to the undergraduate classes.

591. Reading Course at the PhD Level  
*Credit to be arranged*

Reading and analysis of philosophical literature on an advanced level, under supervision of one or more faculty members; written and oral reports.

595. Research at the PhD Level  
*Credit—varies*

999. Writing Dissertation in Residence  
*Credit—none*
Physics and Astronomy

Professors Bigelow (Chair), Blackman, Bodek, Cline, Das, Demina, Douglass, Eberly, Ferbel, Forrest, Frank, Gao, Hagen, Howell, Manly, McFarland, Melissinos, Orr, Quillen, Rajeev, Shapir, Slattery, Teitel, Thorndike, Watson, Wolf, Wolfs

Professor (Research) Duke, Milloni

Assistant Professors Badolato, *Boersma, Garcia-Bellido, Jordan, Mamajek

Senior Scientists Budd, deBarbaro, Ginther, Sakumoto, Zielinski

Visiting Senior Scientist Skulski

Visiting Scientists Carroll, McGowan, Nordhaus

Joint Appointments: Professors Agrawal, Betti, Bocko, Boyd, Conwell (Research), Foster, Knox, McCrory, Meyerhofer, Novotny, Rothberg, Schröder, Simon (Emeritus), Sobolewski, Stroud, Tang, Tarduno, Thomas, Zhong; Associate Professor Ren; Assistant Professor Dery

Visiting Professor Visser

Professors Emeriti Castner, Helfer, Huizenaga, Jacobsen, Knox, Koltun, Okubo, Piper, Savedoff, Sharpless, Sproull, Van Horn

The Department of Physics and Astronomy offers a graduate curriculum leading to a PhD degree in physics and in physics and astronomy. MS degrees (under Plan A) and MA degrees (under Plan B) are awarded only in physics. The entire program of research and study is designed to emphasize fundamental physical principles and to prepare students for academic, industrial, or government employment. The department has strong research efforts in experimental/observational and theoretical areas of astronomy and astrophysics, biological physics, condensed matter physics, high energy/elementary particle physics, mathematical physics, nuclear physics, plasma physics, and atomic, molecular, and optical physics (quantum optics).

The observational astrophysics group is active in the development of advanced detector arrays and instrumentation for space- and ground-based infrared astronomy. Several faculty are involved in space-astrophysics missions such as the NASA Spitzer Space Telescope and Near-Earth Object Camera (NEOCam), and the ESA Herschel Space Observatory. The astrophysics groups use a wide range of ground-based observatories operating across the electromagnetic spectrum and belong to the SMARTS consortium of small remotely operated telescopes. They employ these facilities in observational studies of protostellar evolution and star formation, in protoplanetary disk evolution and planet formation, and in the search for nearby young stars and their planetary systems.

The Theoretical Astrophysics group explores a wide range of phenomena in astrophysical sources from the sun to the most distant active galaxies. As many of the sources in the universe contain magnetized fluids or plasma, the themes of hydrodynamics, magnetohydrodynamics (MHD), and plasma astrophysics have played a role in the department’s theoretical research programs. With computational and analytical approaches, the group explores such issues as the origin of magnetic fields, interstellar clouds and galaxies, accretion disks, the roles of mass outflows and magnetism in the formation and death of stars, and the physics of active galactic nuclei. The group is also actively pursuing new directions of research in planetary dynamics, protoplanetary disks, and planet formation. With colleagues in Rochester’s Department of Earth and Environmental Sciences, the group also investigates the history of Earth’s magnetic field and the origin of planetary magnetism, by study of palaeomagnetism in terrestrial and meteoritic rocks.

The plasma astrophysics/physics group and the Laboratory for Laser Energetics (LLE) have also combined their resources and talents to create a new program in High-Energy Density Laboratory Astrophysics. The use of high-energy density devices like Inertial Confinement Fusion (ICF) lasers for investigations of cosmic environments is a new development in astrophysics, which holds great promise. Increased collaborations between astrophysicists and plasma scientists are essential for progress in this new field and together University of Rochester astro/plasma physicists and LLE scientists are pushing the frontiers of recreating the Universe’s most exotic phenomena.

Research in several areas of biological and medical physics is carried out in the department. Faculty from the School of Medicine and Dentistry with appointments in physics conduct research in advanced techniques in magnetic resonance imaging (MRI) and in various forms of optical spectroscopy and fluorescence imaging, the latter primarily in the context of photodynamic therapy of cancer. Current work in MRI includes diffusion-weighted imaging of the brain and intermolecular multiple-quantum coherence. Other active research areas represented through joint faculty appointments are charge transport in DNA and biomolecular sensing.

Experimental research in condensed matter physics includes surface physics and interfaces of organic semiconductors, ultrafast dynamics of photoexcited electrons, superconducting electronics, quantum computing in solid state, optical properties of nanostructures, photophysics of organic materials, superconductor electronics, and solar cells. Theoretical work focuses in the areas of statistical mechanics and critical phenomena, interface growth, vortex dynamics in superconductors, quantum coherence, as well as electronic structures in inorganic and organic materials.

The particle and nuclear physics groups explore a diverse array of research areas centered on the goals of determining the nature of the fundamental constituents of matter, how these constituents interact, and the role they play in the evolution of the Universe. The group has a large role in energy frontier physics, which builds upon a history of achievement at the Tevatron Collider at the Fermi National Accelerator Laboratory and which is currently working on detecting and analyzing the first collisions from the Large Hadron Collider at CERN in Geneva Switzerland. A second major experimental focus is neutrino physics, with programs at Fermilab and J-PARC designed to understand the properties of neutrinos and their role in the early universe. The group also has experimental programs in nuclear structure (Argonne and Lawrence Berkeley Lab); gravitational wave detection (LIGO); strongly interacting systems of charmed quarks (Cornell); studies of hot, dense nuclear matter (RHIC).
Candidates for the PhD degree are expected to complete eight advanced (400-level or higher) four-credit courses, at least two of which are specialty courses. These courses are usually taken during the first two years of study. A typical program for the PhD degree during the first year would include courses in mathematical methods (401, 402, 404), two courses in quantum mechanics (407, 408), and one each in electrodynamics (415) and statistical mechanics (418), and during the second year would include one or two courses in mathematical methods (405, 406), one or two courses in advanced quantum mechanics (509, 510, 511), one or two other advanced courses (411, 413, 516, 519), and two specialty courses (chosen from 454, 455, 521, 522, 531, 532, 541, 542, 581, 582, and AST 403, 461, 462). Several other advanced astrophysics courses are offered on a less frequent basis. All graduate students are required to take the noncredit Graduate Research Seminar (PHY 597) during their first year.

A written preliminary examination is usually taken during the second year of study, and is intended to assure that each student has a comprehensive grasp of physics at the level of the core curriculum. Following the successful completion of the qualifying examination, which involves an oral presentation to a faculty committee, each candidate for the degree must complete a significant piece of original research, which is then formally presented in the dissertation and which must be defended in the final oral PhD examination. Students are encouraged to begin research activity in their first year of study. All PhD candidates become involved in teaching activity at some point of their studies. This usually means conducting recitation or laboratory sessions in introductory undergraduate courses. One year of teaching is required of each full-time student and a second year is highly recommended. Research and teaching activity is required of all students working toward the PhD degree whether or not they are awarded any form of financial support.

Seminars and colloquia on various topics of research both by visiting and resident physicists and astronomers are scheduled regularly, and constitute an important component of graduate education.

The department offers a BS-MS program in physics and astronomy. Students who wish to go beyond the bachelor’s level may enroll in the department’s five-year BS-MS program. Students are encouraged to apply to the program in the spring of the junior year and can begin graduate-level work in the fourth year. The BS is completed by the end of the fourth year, and requirements for the MS are completed by the end of the fifth year. The MS degree may be pursued via plan A (with master’s thesis) or plan B (with comprehensive exam).

**PHYSICS**

**401. Mathematical Methods in Optics and Physics**  
(***Same as OPT 411***)  
**Prerequisites:** MTH 164, 282, or equivalent.

Study of mathematical techniques such as contour integration, transform theory, Fourier transforms, asymptotic expansions, and Green’s functions, as applied to differential, difference, and integral equations.
402. Probability
Credit—two hours

404. Linear Spaces
Prerequisite: MTH 235 or equivalent.
Credit—two hours

405. Geometric Methods of Physics
Prerequisite: MTH 243 or equivalent.

406. Symmetries in Physics
Prerequisites: PHY 401, 404, or equivalent.
Finite groups. Compact and non-compact Lie groups and Lie algebras. Group representation theory.

407. Quantum Mechanics I

408. Quantum Mechanics II
Prerequisite: PHY 407 or equivalent.
Symmetries including parity, lattice translations, and time reversal. Stationary-state and time-dependent perturbation theory, Stark and Zeeman effects, fine structure, transition probabilities. Scattering theory with applications. Elementary QED, multipole and plane-wave expansions, properties of the photon. The Dirac equation and elementary mass renormalization.

411. Mechanics and Chaotic Dynamics
Prerequisite: PHY 235.
Lagrangian and Hamiltonian dynamics, canonical transformations, Hamilton-Jacobi equations, chaotic dynamics and routes to chaos, Fourier spectrum and Poincaré maps, Lyapunov exponents, strange attractors and fractal dimensions, information dimension and Kolmogorov entropy, numerical tests for chaotic behavior.

412. Computational Methods for Engineering and Science
Prerequisite: ME 402 or PHY 401 or OPT 411, or permission of the instructor. Some FORTRAN experience desirable.

413. Gravitation
Motivation for a metric theory of gravity, principle of equivalence, principle of general covariance, mathematical tools, curvature tensor, Einstein field equations and solutions, energy momentum tensor, weak field approximation, applications, and optional topics.

415. Electromagnetic Theory I
Prerequisite: PHY 401 or may be taken concurrently.

420. Introduction to Condensed Matter Physics
(Same as PHY 251, ECE 420)
An emphasis is made on the wide variety of phenomena that form the basis for modern solid-state devices. Topics include crystals, lattice vibrations, quantum mechanics of electrons in solids, energy band structure, semiconductors, superconductors, dielectrics, and magnets.

428. Physics of Radiobiology II

429. Organic Electronics

431. Nano-optics
(Same as OPT 463)
Prerequisites: advanced calculus and vector analysis, electromagnetic theory (OPT 462 or equivalent), and quantum mechanics (OPT 412 or equivalent).
Nano-optics is an emerging new field of study motivated by the rapid advance of nanoscience and technology. Traditionally, the diffraction limit prevents us from optically interacting with matter on a nanometer scale. However, in recent years several new approaches have been put forth to “shrink” the diffraction limit or to even overcome it. The interaction of light with nanoscale matter renders unique information about structural and dynamical properties. Therefore, optical techniques are of great importance for the study of biological and solid-state nanostructures. The course in nano-optics addresses the key issues of optics on the nanometer scale. Starting with an angular spectrum representation of optical fields, the role of inhomogeneous evanescent fields is discussed. Among the topics are theory of strongly focused light, point spread functions, resolution criteria, confocal microscopy, near-field optical microscopy, and resolution criteria. Further topics are optical interactions between nanoparticles, atomic decay rates in inhomogeneous environments, single-molecule spectroscopy, light forces and optical trapping, theoretical methods in nano-optics.
434. Quantum Optics and Quantum Information Laboratory
An advanced optics teaching laboratory course that exposes the cutting-edge photon counting instrumentation and methods with applications ranging from quantum information to biotechnology and medicine.

435. Laser Systems
(Same as OPT 465)
The design and use of laser systems, emphasizing visible and near-infrared lasers. The course is engineering oriented and covers techniques for measuring laser characteristics as well as a variety of laser applications. An introduction to nonlinear optics is included.

436. Molecular Spectroscopy and Structure
(Same as CHM 458)
The course covers the theory and experimental practice of spectroscopic methods used to study molecules in both gas and condensed phase with an emphasis on the latter.

437. Nonlinear Optics
(Same as OPT 467)
Fundamentals and applications of optical systems based on the nonlinear interaction of light with matter. Topics treated include mechanisms of optical nonlinearity, second-harmonic and sum and difference-frequency generation, photonics and optical logic, optical self-action effects including self-focusing and optical soliton formation, optical phase conjugation, stimulated Brillouin and stimulated Raman scattering, and selection criteria of nonlinear optical materials.

438. Optical Communication Systems
(Same as OPT 468)
Designed to give students a basic understanding of the optical communications systems while making them aware of the recent technological advances. The following topics are covered: components of an optical communication system; propagation characteristics of optical fibers; lightwave sources such as light-emitting diodes and semiconductor lasers; optical receivers; noise analysis and bit-error rate; coherent, multichannel, and soliton-based communication systems.

439. Nonlinear Optical Spectroscopy
(Same as CHM 459, OPT 459)
Covers a broad range of optical spectroscopic techniques and focuses on theoretical methods for their microscopic interpretation. A general correlation function methodology for analyzing nonlinear optic experiments in terms of molecular dynamics and relaxation processes is developed. The relationships between ultrafast (time-domain) and frequency-domain techniques are discussed. Applications are made to fluorescence and Raman spectroscopy, three- and four-wave mixing, photon echo, hole burning, and transient gratings in the gas phase and condensed phases. Optical materials and nanostructures are discussed.

440. Twentieth-Century Particle Physics
(Same as PHY 254)
Describes the properties of nuclei and various models useful for the description of nuclear properties. The models and ideas include the liquid drop model, shell model, collective model, radioactivity, fission, and fusion. Properties of particle interactions with matter are covered and used to develop principles of detections used in nuclear and particle experiments. The physical ideas behind various existing accelerators are discussed. Finally, the fundamental interactions of elementary particles and their constituents are reviewed, with emphasis on issues pertaining to the conservation of quantum numbers and symmetries observed in the high-energy collisions.

445. Advanced Nuclear Science Education Laboratory (ANSEL)
The course focuses on a sophisticated understanding of our terrestrial radiation environment and of some of the important applications of nuclear science and technology. The course covers practical skills in the routine use of radiation detectors, monitors, and electronics, and strengthens the ability to assess radiation threats and prospects of their abatement.

446. Nuclear Science and Technology I
(Same as CHM 466)
The course covers the microscopic structure of nuclei and the dynamics of nuclear collisions; the interaction of nuclear radiation with matter, techniques and applications of radiation detectors, gross properties of nuclei and their structure (shell and collective models), gamma and particle decay of unstable nuclei, nuclear forces and their symmetries, nuclear scattering and reactions, potential scattering, nuclear fusion, and particle transfer.

451. The Physics of Astrophysics I: Radiative Processes
(Same as AST 461)
Prerequisites: PHY 407, 408, 415, 418 in the past or concurrently.
Focuses on the physics of radiation production by ionized and atomic matter, the transfer of radiation through matter, and what is measured from astrophysical objects.

452. The Physics of Astrophysics II: Astrophysical Fluids and Plasmas
(Same as AST 462)
Focuses on hydrodynamic and plasma processes relevant to astrophysics. Fundamentals of fluid dynamics and magnetohydrodynamics, fluid, MHD, thermal instabilities, turbulence, supersonic and subsonic flow. Accretion physics, shocks, dynamos, particle accelerations in plasmas, dynamics of magnetic fields.

454. Introduction to Plasma Physics I
(Same as ME 434)
Orbit theory, adiabatic invariants, MHD equations, waves in plasma, shock waves in plasma, and diffusion across magnetic fields and in velocity space.
455. Introduction to Plasma Physics II
(Same as ME 435)
Prerequisite: PHY 454 or permission of instructor.
Continuation of PHY 454. Vlasov equation, Landau damping, Van Kampen modes, shield clouds, two-stream instability, micro-instabilities, drift instability, and nonlinear instability theory radiation from plasma.

456. Compressible Flow
(Same as ME 436)
Prerequisites: ME 225 and ME 201 or MTH 281.
Acoustics, linearized equations for homogeneous media, mathematical theory of linear waves; waves in stratified atmospheres; geometrical acoustics. Finite amplitude compressible flow; one-dimensional waves and the theory of characteristics; shock waves; steady two-dimensional flow. Radiative transfer; emission and absorption in gases; equation of radiative transfer; radiative effects on waves.

457. Incompressible Flow
(Same as ME 437)
Kinematics, the Navier-Stokes equation, the stream function, vorticity dynamics, laminar viscous flows, slow viscous flow boundary layers, inviscid irrotational flow.

462. Medical Imaging Theory and Implementation
(Same as ECE 452, OPT 452, BME 452)
Prerequisite: ECE 242.
Physics and implementation of X-ray, ultrasonic, and MR imaging systems. Special attention is given to the Fourier transform relations, reconstruction algorithms of X-ray and ultrasonic-computed tomography, and MRI.

464. Biological Physics
(Same as PHY 253)
Physical aspects of special topics in biology. The purpose of this course is to survey several important areas of biological and medical physics. Topics include properties of biological membranes, transport and signaling in cells and tissue, photosynthesis, magnetic resonance imaging, and physical methods in biology such as nuclear magnetic resonance, X-ray diffraction, and optical absorption and fluorescence spectroscopies.

475. Experimental Particle Physics
Prerequisite: permission of instructor.
Students (high school teachers) study the methods and techniques of experimental particle physics research by participating in the design and construction of detectors for classroom-based cosmic ray experiments. (Summer)

491. Reading Course at the Master’s Level
Credit to be arranged
Special study or work, arranged individually for master’s candidates.

492. Certificate in Teaching of College Physics or Physics and Astronomy
Prerequisites: PHY 498, 499, 597 or 598, 599.
After serving as lead teaching assistants (TA), students teach a course during the University’s summer session. Students successfully completing the graduate teaching program are awarded a Certificate of College Teaching in Physics and Astronomy.

493. Special Topics in Physics I
Subject matter to be selected by instructor and students on an ad hoc basis in specific areas at the master’s level.

494. Special Topics in Physics II
Subject matter to be selected by instructor and students on an ad hoc basis in specific areas at the master’s level.

495. Research in Physics (MS)
Independent investigation leading toward a master’s thesis carried out under the supervision of a staff member.

498. Supervised Teaching Assistant I
Credit—none
Designed for students to be laboratory or recitation teaching assistants (TA). Typically, students spend the semester teaching two laboratories during the fall semester for the introductory physics and astronomy courses.

499. Supervised Teaching Assistant II
Prerequisite: PHY 498
Credit—none
A follow-up course of PHY 498. Students, experienced laboratory and recitation leaders, serve as lead teaching assistants (TA). Students spend the semester teaching two laboratories during the spring semester for the introductory physics and astronomy courses.

509. Introduction to Nonrelativistic Many-Body Systems
Prerequisites: PHY 407, 408, or equivalent.
The basic concepts and techniques of many body systems and how they are used to extract physical properties. Techniques covered are second quantizations, Green’s functions, linear response theory, perturbative expansions based on Feynman diagrams, variational methods, and functional methods. Electron gas and other normal Fermi systems, superconductivity, interacting Bose systems and condensation, quantum magnetic systems, localization, etc.

510. Advanced Quantum Mechanics (Relativistic)
Prerequisite: PHY 509.
Review of Dirac equation, covariance and transformation properties of the Dirac equation, propagator theory, applications, second order corrections and renormalization, Klein Gordon equation, non-electromagnetic interactions.
511. Field Theory
Prerequisites: PHY 509 or 510.
Path integral formulation of quantum mechanics, free harmonic oscillator, fermionic oscillator, instantons, free scalar field, Green's functions, generating functional, statistical mechanics as Euclidean field theory, partition function as a path integral, free Bose gas, interacting theories, Green's functions and scattering amplitudes at tree level, symmetry, Ward identities, symmetry breaking and Goldstone theorem, effective action at one loop, 1d Ising model, 2d Ising model, duality, high and low temperature expansions, transfer matrix, scaling of coupling with lattice size.

512. Renormalization
Prerequisites: PHY 509 or 510.
Background and introduction to renormalization, one-loop divergences in perturbation theory, and Callan Symanzik equation. The renormalization group and Wilson's point of view, effective actions, and operator product expansion.

513. Magnetic Resonance Imaging: From Spins to Brains
(Same as BCS 513, BME 513, NSC 513)
Prerequisite: PHY 422 or ECE 452.
Course introduces students to the physics of MR imaging and reviews its application to medical imaging. Discusses how the MR technique can take advantage of physiological principles and tissue structure to provide diagnostic images for clinicians and researchers. Covers what can be learned about brain functions through MR imaging. Introduces functional brain imaging and related issues in data analysis.

516. Electromagnetic Theory II
Prerequisites: PHY 401 and 415; may be taken concurrently.
A continuation of PHY 415 covering special topics, such as physical optics, radiation from moving charges, radiation damping, scattering and electrodynamics in material media.

519. Statistical Mechanics II
Prerequisites: PHY 402, 408, 418.
A continuation of PHY 418, involving the theory of imperfect gases, phase transitions, and Brownian motion.

521. Condensed Matter I
(Same as MSC 550)
Prerequisites: PHY 407, 408, or permission of instructor.
Classification of solids by crystal lattice, electronic band structure, phonons, and optical properties; X-ray diffraction, neutron scattering, and electron screening.

522. Condensed Matter II
(Same as MSC 551)
Prerequisite: PHY 521.
Electron-phonon interaction, transport, magnetism, and topics of current interest such as superconductivity or localization, to be determined by the instructor.

523. Special Topics in Condensed Matter
Prerequisites: PHY 521 and 522 or permission of instructor.
Subject matter to be selected by the instructor from among topics of current interest in solid-state physics.

524. Special Topics in Condensed Matter
(Same as MSC 552)
Prerequisites: PHY 521 and 522 or permission of instructor.
Subject matter to be selected by the instructor from among topics of current interest in solid-state physics.

527. Introduction to Computational Neuroscience
Prerequisite: BCS 512 recommended.
Review various computational theories of how the brain encodes, selects, and represents behaviorally relevant variables, computes over these variables, and modifies its circuitry as a result of experience.

531. Introduction to Quantum Optics
(Same as OPT 551)
Prerequisites: PHY 401, 402, 407, 408, 415 or permission of instructor.
Classical and quantum mechanical theories of the interaction of light with atoms and molecules, with emphasis on near resonance effects, including coherent nonlinear atomic response theory, relaxation and saturation, laser theory, optical pulse propagation, dressed atom-radiation states, and multi-photon processes.

532. Quantum Optics of the Electromagnetic Field
(Same as OPT 552)
Prerequisite: PHY 531 is recommended.
Properties of the free quantized electromagnetic field, quantum theory of coherence, squeezed states, theory of photoelectric detection, correlation measurements, atomic resonance fluorescence, cooperative effects, quantum effects in nonlinear optics.

533. Quantum Optics of the Atom-Field Interaction
(Same as OPT 553)
Prerequisites: PHY 531, 532.
Subject matter to be selected from topics of current interest in quantum optics.

534. Mechanical Effects in the Atom-Field Interaction
(Same as OPT 554)
Subject matter to be selected from topics of current interest in quantum optics.

535. Modern Coherence Theory
(Same as OPT 592)
Prerequisites: PHY 531, 532.
Theory of random process, stationarity ergodicity, the auto-correlation function and the cross-correlation function of random process, Spectrum of a stationary random process and the Wiener-Khintchine theorem, Second-order coherence theory in the space-time domain.
the mutual coherence function, the degree of coherence. Second-order coherence theory in the space-frequency domain, the cross-spectral density, mode representation, propagation problems, inverse radiation problems, effects of source correlations and scattering of partially coherent light from deterministic and from random media.

536. Special Topics in Quantum Optics  
(Same as OPT 556)  
Prerequisites: PHY 531, 532 or permission of instructor.  
The instructor chooses a topic of current interest in quantum optics.

537. Statistical Optics  
(Same as OPT 563)  
Prerequisites: OPT 461 and OPT 462; students are encouraged to take PHY 404 concurrently.  
Topics include elements of applied probability theory: probability theory, random variables, moments of random variables, density and distribution functions, characteristic and moment generating functions, and the central-limit theorem. Introduction to stochastic process: stationarity and ergodicity, correlation functions, power or Wiener spectrum, Gaussian processes, Poisson point processes, compound Poisson point processes. Coherence theory of optical fields, Laser speckle and its applications, photoelectric detection of light.

538. Advanced Topics in Light-Wave Technologies  
(Same as OPT 528)  
Prerequisite: OPT 461; OPT 428 recommended, but not required.  
Course is designed to provide students with understanding of the recent advances in the field of light-wave technology. Topics include background material, fiber Bragg gratings, fiber couplers, interferometers, fiber amplifiers, fiber lasers, pulse compression, fiber-optic communication, optical solitons.

539. Waveguide Optoelectronic Devices  
(Same as OPT 568)  
This course examines in detail principles of operation of modern optoelectronic devices with an emphasis on waveguide devices. Topics generally include dielectric optical waveguides, coupled-mode theory, passive components, electro-optic devices, semiconductor lasers, semiconductor optoelectronic devices, and fiber lasers and amplifiers.

541. Nuclear Structure I  
Prerequisite: PHY 408 or permission of instructor.  
Nuclear models and symmetries in nuclei; shell model, models pertinent in regions of strong pairing interactions, including BCS and generalized seniority; the microscopic theory of vibrations; rotational structures in heavy and light nuclei.

542. Nuclear Structure II  
Prerequisite: PHY 541.  
Electromagnetic and weak transitions; sum rules, introduction to nuclear reactions, theory of nuclear forces.

544. Special Topics in Nuclear Physics  
Prerequisites: PHY 541, 542.  
Subject matter to be selected from among advanced topics in the theory of nuclear structure and nuclear reactions.

546. Nuclear Science and Technology II (Nuclear Chemistry II)  
(Same as CHM 566)  
Prerequisites: PHY 446/CHM 466.  
Experimental and theoretical studies of heavy-ion scattering and reaction mechanisms; semiclassical and quantal scattering theory; Coulomb excitation; few-nucleon transfer; damped heavy-ion reactions; fusion and fission processes; statistical approaches to complex nuclear reaction mechanisms.

552. Magnetohydrodynamics  
(Same as ME 532)  
Equations of magnetohydrodynamics. Kinematical theory of magnetic field transport; equilibrium and stability; incompressible MHD flows; magnetoacoustic waves; MHD shock waves. Kinetic theory foundations of MHD and selected applications, such as flowmeters, the dynamo problem, solar wind, and sunspots.

553. Laser-Plasma Interactions  
(Same as ME 535)  
Prerequisite: PHY 426 or permission of instructor.  

554. Cosmology  
(Same as AST 554)  
Introduction to cosmology, covering the following broad topics: introduction to the universe, introduction to general relativity, cosmological models and Friedmann-Walker universe, thermodynamics of early universe, particle physics of the early universe, and the formation of large-scale structure.

555. Advanced Topics in Plasma Physics  
(Same as ME 545)  
Course varies year to year. Topics include controlled fusion reactor concepts, including laser fusion, energy in the future, space plasmas, and astrophysical plasma phenomena.

556. Hydrodynamic Stability and Turbulence  
(Same as AST 554)  
557. Plasma Stability  
(Same as ME 534)  
Prerequisite: ME 434 or permission of the instructor.
Stability of magnetically confined plasma, delta-W formalism, double adiabatic equation, comparison theorem, shear stabilization, minimum-beta fields, resistive instabilities, Tokamak and Mirror stability theory.

558. Inertial Confinement Fusion  
(Same as ME 533)  

564. High-Energy Astrophysics  
(Same as AST 564)  
Prerequisite: AST 461, 462.  
A survey of current research topics in high energy astrophysics. Topics drawn from X-ray and gamma-ray astrophysics, supernovae and planetary nebulae, binary accretors, astrophysics of compact objects (black holes, neutron stars, white dwarfs), plasma astrophysics, magnetic field-particle interactions, cosmic rays, astrophysical jets, active galactic nuclei.

581. Particle Physics I  
Prerequisites: PHY 408, PHY 509 concurrently.  

582. Particle Physics II  
Prerequisite: PHY 509.  
Electroweak theory, and experimental evidence in support of it. Gauge theories and spontaneous symmetry breaking. QCD and color SU(3). Grand unification and recent advances. Particles and cosmology.

584. Special Topics in Particle Physics  
Prerequisite: PHY 582.  
Subject matter to be selected from topics of current interest in particle physics.

591. Reading Course at the PhD Level  
Credit to be arranged  
Special study or work, arranged individually.

593. Special Topics in Physics I  
Subject matter to be selected from among advanced topics of current interest. Course has separate sections dealing with diverse topics.

594. Special Topics in Physics II  
See PHY 593, which is not prerequisite.

595. Research at the PhD Level  
Credit to be arranged  
Independent investigation leading toward a doctoral thesis carried out under the supervision of a staff member.

597. Graduate Teaching and Research Seminar  
Credit—none  
Course given once per week, required of all first-year graduate students. Consists of lectures and discussions on various aspects of being an effective teaching assistant, including interactions with undergraduate student body and cross-cultural issues. Faculty members discuss topics in their current area of research interest.

598. Teaching Workshop Leader Pedagogy Training  
Credit—none  
Designed for Workshop Leader teaching assistants (TA). Typically, TAs attend weekly Workshop Leader training meetings that offer specialized support and training in group dynamics, learning theory, and science pedagogy for students facilitating collaborative learning groups for science and social science courses. TAs teach three to four workshops in one of the fall semester introductory physics courses.

599. Pedagogy and Group Leadership  
Prerequisite: PHY 598.  
Credit—none  
Designed as a follow-up course for an experienced Workshop Leader. TAs typically attend weekly Workshop Leader training meetings that offer specialized support and training to develop leadership skills, foster ongoing communication among faculty members and study group leaders, and provide review of study group–related issues. Students spend semester teaching three to four workshops during the spring semester introductory physics courses.

999. Doctoral Dissertation  
Credit—none  
Writing dissertation.

ASTRONOMY

403. Experimental Techniques in Astronomy  
Prerequisites: the equivalent of PHY 217–218, ME 201, and PHY 227.  
Introduction to the tools of modern observational astronomy. Discussions of geometrical and physical optics applied to telescopes and astronomical cameras; the physics of light detection at radio, infrared, visible, X-ray, and g-ray wavelengths; and the instruments and techniques used for observations of faint celestial objects over the full useful range of spectral and angular resolution. The intention is to provide to students the preparation necessary to design, build, and optimize astronomical instruments.
However, the material should be useful to anyone who will be using remote-sensing instruments, astronomical or otherwise, or is seeking to understand measurements made with these devices.

450. Stellar Atmospheres  
*Prerequisites: PHY 407–408 and 418, in the past or concurrently.*


453. Introduction to Stellar Interiors and Stellar Atmospheres  
*Prerequisites: PHY 407–408, 418, in the past or concurrently.*

A first course on stellar interiors and atmospheres in which approximately 50 percent of a semester is devoted to each. See AST 450 and 553 for full-fledged courses.

455. Astronomical Interferometry  
*Prerequisites: AST 403, PHY 415.*

Introduction to the principal technique of modern radio astronomy, and an increasingly important tool for infrared and visible wavelengths: spatial interferometry. We discuss the elements of physical optics, coherence theory, and the physics of detectors and receivers that bear on astronomical interferometry. We follow this formal development with a detailed account of the practice of interferometry, calibration, and data reduction. The intention is to provide to students all they need to know to understand, plan, propose, and analyze observations with such instruments as the Very Large Array (VLA), the Very Long Baseline Array (VLBA), the Owens Valley Radio Observatory’s (OVRO) Millimeter Array, and the Berkeley-Illinois-Maryland Array (BIMA) at Hat Creek Radio Observatory.

461. The Physics of Astrophysics I: Radiative Processes  
*Prerequisites: PHY 407–408, 415, 418, in the past or concurrently.*

Focuses on the physics of radiation production by ionized and atomic matter, the transfer of radiation through matter, and what we measure from astrophysical objects.

462. The Physics of Astrophysics II: Astrophysical Fluids and Plasmas  
*(Same as PHY 452)*

Focuses on hydrodynamic and plasma processes relevant to astrophysics. Fundamentals of fluid dynamics and magnetohydrodynamics, fluid, MHD, thermal instabilities, turbulence, supersonic and subsonic flow. Accretion physics, shocks, dynamos, particle accelerations in plasmas, dynamics of magnetic fields.

465. Observational Galactic Structure  

Star, gas, and dust distribution in our galaxy. Structure studies and classification of other galaxies. Clusters of galaxies, red shifts, Seyfert galaxies, peculiar galaxies, quasars.

495. MS Research in Astrophysics  

Independent investigation leading toward a master’s thesis carried out under the supervision of a staff member.

553. Stellar Interiors  
*Prerequisite: AST 461–462 or AST 453.*


554. Cosmology  
*(Same as PHY 554)*

Introduction to cosmology, covering the following broad topics: introduction to the universe, introduction to general relativity, cosmological models, and Friedmann-Walker universe, thermodynamics of early universe, particle physics of the early universe, and the formation of large-scale structure.

563. Seminar on Radio Astronomy  

A survey of current research reports in scientific journals on topics including research on pulsars, quasars, and radio and infrared observations of the interstellar medium.

564. High Energy Astrophysics  
*(Same as PHY 564)*  
*Prerequisites: AST 461, 462.*

A survey of current research topics in high energy astrophysics. Topics drawn from X-ray and gamma-ray astrophysics, supernovae and planetary nebulae, binary accretors, astrophysics of compact objects (black holes, neutron stars, white dwarfs), plasma astrophysics, magnetic field-particle interactions, cosmic rays, astrophysical jets, active galactic nuclei.

565. Formation of Stars and Planetary Systems  
*Prerequisites: PHY 235, 227, AST 241 (AST 461 and 462 are helpful), or permission of instructor.*

Survey of theory and multiwavelength observations related to the formation of early evolution of stars and planets. Interstellar medium, interstellar dust, molecular clouds, protostars, T Tauri stars, circumstellar disks, pre-main sequence stellar evolution, extrasolar planets and substellar objects, constraints on the protosolar nebula from meteorites and the planets.

570. Solar System Dynamics  
*Prerequisites: AST 461, 462, 465.*

Dynamics of bodies in the solar system and exosolar systems are explored with an emphasis on applying results to the interpretation of exoplanetary systems. Topics covered are two-body problem, orbital elements, f and g functions, universal variables for hyperbolic and eccentric orbits. Hamiltonian formulation, canonical transformations, symplectic integrators, hyperbolic orbits, impulse approximations, dynamical friction, gravitational stirring, three-body problem, Jacobi integral, Tisserand relation, disturbing function, low eccentricity expansions, secular perturbations, mean motion resonances, resonant trapping, dust dynamics, Yarkosky effect.
591. Reading Course at the PhD Level  
Credit to be arranged  
Special study or work, arranged individually.

593. Theoretical Astrophysics Seminar  
Current theoretical topics of interest are explored in considerable detail. Topics vary from year to year and reflect research interests of staff.

594. Observational Astrophysics Seminar  
Current topics of observational or experimental interest are explored in considerable detail. Topics vary from year to year and reflect research interests of staff.

595. Research at the PhD Level  
Credit to be arranged  
Independent investigation leading toward a thesis carried out under the supervision of a staff member.

999. Doctoral Dissertation  
Credit—none  
Writing dissertation.

Political Science

Professors Duggan, Jackson, Jacobs, Johnson, Niemi, G. Powell, L. Powell, Rothenberg, Seligman, Stone  
Associate Professors Clarke, Fey, Gamm, Helmke (Chair), Goemans, Kalandrakis, Meguid, Primo, Signorino  
Assistant Professors Acharya, Jordan, Lacina, Peress  
Professors Emeriti Bluhm, Fenno, Phelps, Regenstreif

The Department of Political Science offers a program of graduate study leading to the degree Doctor of Philosophy. The primary purpose of the PhD program is to train scholars who will contribute to the future development of the discipline of political science through careers in teaching and research. The program at Rochester involves a distinctive approach to studying politics that emphasizes the development of formal theory and the analysis of quantitative evidence. The doctoral program is designed to require five years of study of which the fourth and fifth years are occupied with the dissertation.

The doctoral program requires at least four, and usually five, years of full-time study. All entering students are expected to have a basic command of spoken and written English, as well as the equivalent of one year of college-level calculus.

Students must complete at least 14 regular courses in the PhD program, usually by the end of their third year, as well as the math “prefresher.” For most PhD students the first year of study is spent completing courses in the required theoretical and methodological sequences (PSC 404, 405, 407, 408, and 480) and exploring some substantive fields. The second year is spent on substantive concentration and research culminating with the presentation of a research paper in the beginning of year three. All candidates for the PhD degree become involved in teaching during their third and fourth years. The PhD comprehensive examinations in three fields of concentration normally are completed by the second semester of the third year; at least one of these fields must be statistical methods or formal theory. A Master of Arts degree is awarded at this stage. Writing the PhD thesis is the major task of the remainder of the program.

The available fields are as follows: American Politics, Comparative Politics, International Relations, Political Philosophy, Methods, and Formal Theory.

The following courses carry 4 credit hours, unless otherwise noted. See a complete listing of degree requirements on the department website: www.rochester.edu/college/psc/graduate/degree.php.

METHODOLOGY

404. Probability and Inference

405. Linear Models

505. Maximum Likelihood Estimation  
Prerequisite: PSC 405.
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Prerequisites</th>
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</thead>
<tbody>
<tr>
<td>506</td>
<td>Advanced Topics in Methods</td>
<td>Prerequisite: PSC 505 or permission of instructor.</td>
</tr>
<tr>
<td>507</td>
<td>Computational Methods</td>
<td></td>
</tr>
<tr>
<td>510</td>
<td>Political Parties and Elections</td>
<td></td>
</tr>
<tr>
<td>511</td>
<td>Public Opinion and Electoral Behavior</td>
<td></td>
</tr>
<tr>
<td>512</td>
<td>Voting and Elections</td>
<td></td>
</tr>
<tr>
<td>513</td>
<td>Interest Groups (pending school approval)</td>
<td></td>
</tr>
<tr>
<td>516</td>
<td>Political Participation</td>
<td></td>
</tr>
<tr>
<td>518</td>
<td>Emergence of the Modern Congress</td>
<td></td>
</tr>
<tr>
<td>519</td>
<td>American Legislative Institutions</td>
<td></td>
</tr>
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<td>523</td>
<td>American Politics Field Seminar</td>
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<tr>
<td>525</td>
<td>Race and Political Representation</td>
<td></td>
</tr>
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<td>530</td>
<td>Urban Change and City Politics</td>
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<td>535</td>
<td>Bureaucratic Politics</td>
<td></td>
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<tr>
<td>540</td>
<td>Models in American Politics: Theory and Data</td>
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<tr>
<td>550</td>
<td>Comparative Politics Field Seminar</td>
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<tr>
<td>551</td>
<td>Western European Politics</td>
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<tr>
<td>555</td>
<td>Democratic Processes</td>
<td></td>
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<tr>
<td>556</td>
<td>Political Economy of Reform</td>
<td></td>
</tr>
<tr>
<td>558</td>
<td>Comparative Parties and Elections</td>
<td></td>
</tr>
<tr>
<td>564</td>
<td>Comparative Political Economy</td>
<td></td>
</tr>
<tr>
<td>471</td>
<td>Russia and Eastern Europe: Politics and International Relations</td>
<td></td>
</tr>
<tr>
<td>479</td>
<td>War and the Nation-State</td>
<td></td>
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<tr>
<td>571</td>
<td>Quantitative Approach to International Politics</td>
<td></td>
</tr>
<tr>
<td>572</td>
<td>International Politics Field Seminar</td>
<td></td>
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<tr>
<td>573</td>
<td>Territory and Group Conflict</td>
<td></td>
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<tr>
<td>574</td>
<td>International Political Economy</td>
<td></td>
</tr>
<tr>
<td>576</td>
<td>Modeling International Conflict</td>
<td></td>
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<tr>
<td>577</td>
<td>Theories of Conflict</td>
<td></td>
</tr>
<tr>
<td>578</td>
<td>International Conflict: Theory and History</td>
<td></td>
</tr>
<tr>
<td>579</td>
<td>Politics of International Finance</td>
<td></td>
</tr>
<tr>
<td>407</td>
<td>Mathematical Modeling</td>
<td></td>
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<tr>
<td>408</td>
<td>Positive Political Theory</td>
<td></td>
</tr>
<tr>
<td>575</td>
<td>Political Economy I</td>
<td></td>
</tr>
<tr>
<td>580</td>
<td>Political Economy of Development</td>
<td></td>
</tr>
<tr>
<td>582</td>
<td>Political Economy II</td>
<td></td>
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<tr>
<td>584</td>
<td>Game Theory</td>
<td></td>
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<tr>
<td>586</td>
<td>Voting and Elections</td>
<td></td>
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<tr>
<td>588</td>
<td>Bargaining Theory and Applications</td>
<td></td>
</tr>
<tr>
<td>480</td>
<td>Scope of Political Science</td>
<td></td>
</tr>
<tr>
<td>484</td>
<td>Democratic Theory</td>
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</tr>
<tr>
<td>581</td>
<td>Philosophical Foundations of Political Science</td>
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<tr>
<td>583</td>
<td>Culture and Politics</td>
<td></td>
</tr>
<tr>
<td>491</td>
<td>Reading Course at the Master’s Level</td>
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<tr>
<td>591</td>
<td>Reading Course at the PhD Level</td>
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<tr>
<td>595</td>
<td>Research at the PhD Level</td>
<td></td>
</tr>
</tbody>
</table>
Center for Visual Science

Professors Aslin, Bavelier, DeAngelis, Duffy, Feldon, Fienup, Jacobs, Knill (Associate Director), Knox, Lennie, MacRae, Mergian, Paige, Pasternak, Pouget, Rolland, Schieber, Williams (Director)
Associate Professors Freedman, Gan, Huxlin, Romanski, Yoon, Zavislan
Assistant Professors Chung, Hayden, Hindman, Hunter, Libby, Mahon, Majewska, Tadin
Adjunct Associate Professor DiLoreto

The Center for Visual Science provides specialized coursework and advanced research facilities for graduate students and post-doctoral students in various disciplines that involve the field of visual science. This is done with the cooperation of faculty who have their primary appointments elsewhere in the University. Prospective students with an interest in this area might be drawn from any one of the following departments: brain and cognitive sciences, biomedical engineering, neurobiology and anatomy, neuroscience, neurology, optics, ophthalmology, and computer science. Courses in the Center for Visual Science are available to any graduate student working toward degrees in any of the regular departments of the University.

VISION COURSES

448. Vision and the Eye
(Same as BCS 526 and OPT 448)

504. Sensory Systems
(Same as BCS 504)

505. Perception and Motor Systems
(Same as BCS 505)

524. Advanced Problems in Perception and Action
(Same as BCS 524)

Visual and Cultural Studies Program

Professors Berlo, Crimp, DiPiero, Duro, Foster, Michael, Willis
Associate Professors Haidu, Saab
Affiliated Faculty: Professors Bernardi, Gustafson, Schaefer;
Associate Professors Scheie, Seiberling, Tucker, Wolcott; Assistant Professors Creech, Doran, Hwang, Kim, Middleton, Niu, Reichman

An interdisciplinary program in Visual and Cultural Studies at the University of Rochester, this is one of the few programs in the country that offers graduate degrees with an emphasis on art, media, and film theory, criticism, and cultural studies.

The program offers students the chance to earn a doctoral degree by doing intensive work in several of Rochester’s humanities departments. Primary faculty for the Visual and Cultural Studies Program teach in the Departments of Art and Art History, Anthropology, English, Modern Languages and Cultures, and the Eastman School of Music. Students may also take courses from other departments, for example in history, or education, as part of their studies.

The program stresses close interpretation of art, film, and media within social and historical frameworks. Students are able to relate recent developments in literary and cultural theory to visual works and to investigate the interrelationships between critical texts and visual culture. The graduate program encourages students not only to gain detailed knowledge about their chosen field, but also to develop critical, analytical skills. Students explore culture in its social and historical context, and employ a variety of critical methods and perspectives.

Rochester’s Program in Visual and Cultural Studies is one of the few in the country that offers a doctorate in interdisciplinary critical theory and visual studies. It is also unique in its strong emphasis on the analysis of visual culture.

There are currently 30 graduate students in residence in the program.

VISUAL AND CULTURAL STUDIES COLLOQUIUM

AH 583. Colloquium in Visual and Cultural Studies

CORE AND ELECTIVE COURSES*

AH 411. The American Landscape
AH 412. Modern Architecture
AH 413. Race and Gender in Popular Film
AH 414. Beyond the Boundaries

* Offerings vary from year to year. Arrangements may be made for directed courses in studio.
AH 415. Contemporary Art: Theory and Practice
AH 427. The Poetics of Television
AH 431. Terror, Excess, and Revolution: Romanticism in European Art
AH 437. The Architecture of Frank Lloyd Wright
AH 450. Age of Baroque
AH 455. American Art
AH 456. Film History: 1929–1959
AH 459. Women, Cloth, and Culture
AH 462. Impressionism and Post-Impressionism
AH 463. Twentieth-Century Art and Culture
AH 466. African-American Visual Culture
AH 474. Cultural History of American Architecture
AH 477. The Museum and “the Other”
AH 481. Art and the City: New York in the '70s
AH 482. Renaissance Art: Space, Narrative, Form
AH 487. Culture on Display
AH 492. The Modern City
AH 500. Reconsidering Roland Barthes
AH 506. The Sublime
AH 507. Rhetoric of the Frame
AH 508. Art and Imitation: Mimesis and the Origins of Modern Picturing in Art and Culture
AH 512. Postwar Art and Theory: The Sixties
AH 515. Feminism and Visual Culture
AH 520. The Politics of Space
AH 521. Word and Image
AH 525. Contemporary Art and Culture
AH 526. New Histories of Postwar Art II
AH 554. The Films of Jean-Luc Godard
AH 556. Theorizing Documentary
AH 568. Art of the Colonial Encounter
AH 584. The Visual Culture of Heritage and Identity
ANT 426. Culture and Consumption
ANT 466. Global Culture
ANT 467. Fashion, Beauty, Power
ANT 551. Meaning and Emotion in Culture
CLT 405C. French Avant-Garde(s)
CLT 411B. French Film: The New Wave
CLT 412G. Nazi Culture
CLT 412J. Avant-Garde Film
CLT 419. Contemporary Popular Film: Race and Gender
CLT 434. Queer Theory
CLT 447. The Holocaust: Aesthetics of Representation and Negotiation
CLT 454. Psychoanalysis and Cultural Studies
CLT 457. Kristeva
CLT 480. Feminist Film Theory
CLT 481. Popular Film: Sex and Violence
CLT 481A. Contemporary French Thought
CLT 481B. Freud, Lacan, and Contemporary Thought
CLT 482. Marx and Marxism
CLT 482A. Nietzsche and the Nietzscheans
ENG 437. Marxism and Feminism
ENG 457. Media Studies
ENG 458. Feminism, Criticism, and Culture
ENG 488. Marxist Cultural Theory
ENG 551. Critical Theory—Foucault
ENG 552. Post-Colonial Theory
ENG 542. The African-American Postmodern
ENG 553. Feminist Theory
HIS 482. Topics in Twentieth-Century American Cultural History
SA 491. Independent Studio

Interdisciplinary Master’s Programs

Arts and Sciences, in recognizing the diverse interests of students, has developed and formalized interdisciplinary master’s programs. A standing committee of faculty acts as a “department” and supervises the program requirements for its students.

Literary Translation Program

Professors 2DiPiero, 1Gustafson, 2Jörgensen, 1London, 1Michael, 2Schaefer, 1Scott
Assistant Professor 1Grotz

Literary translation, an interdisciplinary master’s program at the University of Rochester, provides a multifaceted approach to the art, technique, and business of translation by combining academic rigor, strong practical training, and intensive professional development through internships with Open Letter, the University’s renowned imprint for literature in translation. The Literary Translation Program includes a graduate certificate and a Master of Arts degree. The Master of Arts in literary translation is for those preparing for careers as literary translators.

Requirements for the Master of Arts

The Literary Translation Program is composed of three components: a core, electives, and an annotated translation that serves as the Master’s Essay (for a Plan B program) or a thesis (for a Plan A program). (A graduate certificate in literary translation is also available. Students follow the same curriculum as master’s students but do not complete the thesis.)

The core introduces students to the theories and problems of literary translation; furnishes them with a framework in which to work on a series of short- to medium-length translations independently and in consultation with their advisor; and provides a writing workshop in which they can hone their writing skills not merely as literal translators, but as translators of literature.

For their elective requirements, students may pursue at an advanced level their study of specific national literatures and of international literature as a global phenomenon. They may also elect to work as interns at a literary press.

The annotated translation is a book-length literary translation into English, accompanied by commentary addressing the particular problems the students encountered with the work and a description of their resolution. It is expected that the translation be of near publishable quality. The very best translations are considered for publication by the Open Letter press.

* Primary appointment in another department
1 Department of English
2 Department of Modern Languages and Cultures
Admission
- Bachelor's degree or higher in related field
- Significant knowledge of at least one language and literary tradition other than English
- An online application
- Official transcripts
- Three letters of recommendation
- Personal statement describing career and educational goals and prior experience with literary studies, translation, and languages other than English
- Translation sample (approximately 20 pages of fiction or drama, 200 lines of poetry) and copies of corresponding pages from source text

Courses
The Literary Translation Program is composed of three components:

I. Core Components—12 credits
II. Elective Components—12 credits
III. Translation Project Component—6 credits

All component courses are subject to school approval.

I. CORE COMPONENTS

Element 1 (required)
Studies in Translation
This course introduces students to the theoretical backgrounds, practical challenges, and creative activity of literary translation. It surveys appropriate theories of language and communication, including semiotics, poststructuralism, pragmatics, discourse analysis, and cognitive linguistics. This course considers varied and conflicting descriptions by translators of what it is they believe they are doing and what they hope to accomplish by doing it. Further, students study specific translations into English from a variety of sources in order to investigate the strategies and choices translators make and the implication of those choices for developing a sense of the kinds of texts translations actually are. Finally, students undertake, in consultation with the instructor or with another qualified faculty member, exercises in translation of their own. By the end of this class, each student possesses a working knowledge of both the critical backgrounds and the artistic potentials of translation.

Element 2 (required)
Independent Project and Translation Portfolio
Under the direction of an advisor, students complete an independent translation project—a group of poems or stories, a novella, or an excerpt from a novel or play—that becomes the centerpiece of their translation portfolio. The translation portfolio also includes other translations done independently as well as those done for other components of the program.

Element 3 (required)
Fiction or Poetry: Writing and Translation Workshop
To capture the subtleties of the original literary work and communicate its unique aspects in English, a translator must be a skilled and versatile writer in control of style and structure. Element 3 in the Literary Translation Program is designed to provide students with opportunities to share and critique works-in-progress with other literary translation students and creative writers.

II. ELECTIVE COMPONENTS

Element 4
Studies in International Literature
Focusing on literary works from a number of different national cultures, these courses, which are offered through several departments and change from semester to semester, explore the interactions of literatures from different national contexts. By definition, international literature treats more than one culture and involves the study of thematic and stylistic differences, as well as connections between and among cultures. Special attention is paid to the critical issues of intercultural influence and transmission. Courses in international literature analyze how one culture understands another through literary representation. To that end, these courses explore topics related to the movements of people and cultures within the context of globalization, and they do so by focusing specifically on the literary text. Issues for discussion may include the way different national literatures influence each other, how ideas of the literary transform and are transformed by their travel into different cultures, how literature circulates in an international context, and how international culture makes and breaks literary reputations. Students are invited to investigate why the category of international literature exists in the first place, its ramifications for individual cultures and for the world, and the problems and possibilities such a category poses.

Element 5
Advanced Literary Studies
To gain more in-depth knowledge of a specific area of literature, students may choose to focus their studies with graduate literature courses. In consultation with an advisor, students may choose appropriate courses at the 400 level or higher from the Departments of Modern Languages and Cultures, English, and/or Religion and Classics.

For current representative courses, please see listings in the Departments of English, Modern Languages and Cultures, and Religion and Classics.

Element 6
Publishing Practices and Internship
Literary translation students interested in pursuing a career in translating or publishing are encouraged to participate in one of the following internship programs:
Editorial Internships with Rochester’s Open Letter press—Editorial interns have the opportunity to research literature from around the world and to work with international publishers and foreign agencies to obtain information on untranslated authors. Interns are responsible for reading and reporting on untranslated texts, providing sample translations of books under consideration, and writing for the LTS/Open Letter press website.

International Publishing Internships—A limited number of international internships may also be available to literary translation students at publishing houses in France, Germany, Spain, Mexico, Italy, and Japan.

Domestic Publishing Internships—Literary translation students may be able to intern with U.S. publishing houses or literary magazines involved in international literature, such as New Directions, Archipelago Books, and Graywolf.

III. THESIS COMPONENT

Element 7
Final Translation Project

Under the direction of an advisor, students complete a book-length translation of a complete work or of a significant selection of a complete work large enough to be presented to a press for publication. The translation is accompanied by an analysis addressing the significant theoretical and practical problems encountered in the work’s translation. The translation also contains a short critical introduction, which addresses issues such as the selection of author; the selection of texts in the case of a thesis that is not a translation of a stand-alone work; the balance of cultural and linguistic fidelity with literary readability; how the translation itself is a new way of understanding the source text; translation as literary theory; and potential appeal and market of the translation.

Susan B. Anthony Institute for Gender and Women’s Studies

Professor Honey Meconi (Director)

The Susan B. Anthony Institute for Gender and Women’s Studies offers a formal Graduate Certificate in Gender and Women’s Studies for students who are enrolled in a graduate degree (master’s or PhD) program at the University of Rochester and for nonmatriculated students who complete four or more courses from at least two University of Rochester graduate programs (see www.rochester.edu/college/wst).

Gender and women’s studies focuses on the experiences of diverse groups of women and the changing cultural, economic, political, and psychological relations between women and men. Because women’s studies asks questions about women and about gender that no single academic department is able to answer, the program encourages an interdisciplinary approach to research and learning. The Susan B. Anthony Institute includes faculty associates in the humanities, social sciences, and sciences from all six colleges in the University.

The Graduate Certificate in Gender and Women’s Studies provides analyses of contemporary theoretical frameworks and methodologies; a historical perspective on gender and women’s studies within and across disciplines; a focus on issues of gender, race, class, and ethnicity; and connections between academic and nonacademic practices. The certificate becomes part of the student’s record and serves to document training in gender and women’s studies. It is designed to appeal to (1) matriculated graduate students who will apply for teaching positions at the post-secondary level (the certificate complements students’ credentials in their primary discipline by demonstrating scholarly competence in a related, interdisciplinary field and prepares students to offer a wider range of courses at employing institutions); and (2) nonmatriculated students who are interested in obtaining an interdisciplinary training in gender and women’s studies but who do not wish to commit to a full degree program. This training is appropriate for those expanding upon and updating their undergraduate education, preparing for further graduate study, and/or desiring to link their current occupations with recent developments in women’s studies.
W. Allen Wallis Institute of Political Economy

Professors Duggan, Rothenberg
Associate Professors Fey, Stone, Kalandrakis, Primo
Assistant Professors Peress, Caetano, Pancs

The Wallis Institute supports graduate training in political economy for students in the Department of Economics and the Department of Political Science. Prospective students who seek to specialize in this area should apply to the PhD program in one of those two departments. Students admitted to the economics or political science program are subject to the requirements of their program, and they may choose to take advanced graduate seminars in political economy. The Wallis Institute provides a two-course sequence in political economy taught by faculty from the parent departments. Students in economics may take the sequence and write a qualifying exam to fulfill the requirements for the political economy field, and students in political science may take the sequence as part of the requirements for the formal political theory field.

In addition to course offerings, the Wallis Institute runs a seminar series that allows Rochester faculty and students to present their work, and it brings in top researchers across the field from other departments. The institute sponsors post-docs and other visitors and encourages interaction with graduate students. Finally, students are invited to attend an annual conference organized by the institute that continues to serve as a focal point of the political economy field.

The first course in the political economy sequence typically emphasizes foundational theory, and especially connections to the theory of social choice. The goal of the course is to give students in political economy a firm theoretical grounding for their work. The second course may cover a range of topics from elections to legislative policy and makes use of methods from formal modeling, computational analysis to empirical methods. Content of the course may vary with the instructor.

575. Political Economy I
(Same as PSC 575, ECO 575)
The course takes up foundational topics in theoretical political economy. It begins with the analysis of fundamental concepts of preference and choice used throughout the course. The course then covers the main results in social choice theory, where collective decisions are viewed as the product of an abstract process of preference aggregation. Results covered include Arrow’s impossibility theorem and Black’s median voter theorem. The course then moves to the game-theoretic analysis of elections, voting, and legislative bargaining, with a special focus on connections to social choice theory. Content of the course may vary with the instructor.

582. Political Economy II
(Same as PSC 586, ECO 582)
Prerequisite: PEC 575 is recommended (but not required).
The course builds on the theoretical foundations of Political Economy I and delves into the topics of elections, voting, and legislative policy making. Specialized topics may include candidate motivations, strategic voting, lobbying, and taxation, among others. The methodological focus of the course may range from formal modeling to computational analysis to empirical methods. Content of the course may vary with the instructor.
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School of Engineering and Applied Sciences

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Associate Professor of Computer Science

Daniel Stefanovic, PhD (Chicago)  
Associate Professor of Computer Science

Axel Wismueller, MD (Tech. Univ. of Munich, Germany)  
Associate Professor of Biomedical Engineering and of Imaging Sciences

Hui Wu, PhD (California Institute of Technology)  
Associate Professor of Electrical and Computer Engineering

Matthew Yates, PhD (Texas–Austin)  
Associate Professor of Chemical Engineering

Geun-Young Yoon, PhD (Osaka University)  
Associate Professor of Ophthalmology, of Biomedical Engineering, of Optics, and in the Center for Visual Science

James M. Zavislan, PhD (Rochester)  
Associate Professor of Optics, of Biomedical Engineering, of Dermatology, of Ophthalmology, and in the Center for Visual Science; Director of Institute Ventures

Hani A. Awad, PhD (Cincinnati)  
Assistant Professor of Biomedical Engineering and of Orthopaedics

Ahmet Becene, PhD (Rochester)  
Assistant Professor of Mechanical Engineering

Danielle Benoit, PhD (Colorado)  
Assistant Professor of Biomedical Engineering and in Musculoskeletal Research Center

David Berg, MS (Rochester)  
Adjunct Assistant Professor of Optics

Jeffrey Bigham, PhD (Washington)  
Assistant Professor of Computer Science

Edward B. Brown, PhD (Cornell)  
Assistant Professor of Biomedical Engineering

Dale A. Buralli, PhD (Rochester)  
Adjunct Assistant Professor of Optics

Wanli Chi, PhD (Rochester)  
Assistant Professor (Research) of Optics

Regine Choe, PhD (Pennsylvania)  
Assistant Professor of Biomedical Engineering

Lisa A. DeLouise, PhD (Pennsylvania State)  
Assistant Professor of Dermatology, of Biomedical Engineering, and of Electrical and Computer Engineering

Hanan Dery, PhD (Israel Institute of Technology)  
James P. Wilmot Distinguished Assistant Professor in Arts, Sciences & Engineering and Assistant Professor of Electrical and Computer Engineering

Marvin Doyley, PhD (London)  
Assistant Professor of Electrical and Computer Engineering

Jonathan Ellis, PhD (Delft University of Technology, Netherlands)  
Assistant Professor of Mechanical Engineering and Optics

David Foster, PhD (Rochester)  
Adjunct Assistant Professor of Biomedical Engineering

Luca Guazzotto, PhD (Rochester)  
Assistant Professor (Research) of Mechanical Engineering

Andrew Hesford, PhD (Illinois, Urbana-Champaign)  
Assistant Professor (Research) of Electrical and Computer Engineering

Jeff Houck, PhD (Iowa)  
Adjunct Assistant Professor of Biomedical Engineering

Engin Ipek, PhD (Cornell)  
Assistant Professor of Computer Science and of Electrical and Computer Engineering

Mathew Jacob, PhD (Swiss Federal Institute of Technology)  
Assistant Professor of Biomedical Engineering, of Imaging Sciences and of Electrical and Computer Engineering

T. Florian Jaeger, PhD (Stanford)  
Assistant Professor of Brain and Cognitive Sciences, of Computer Science, and in the Center for Visual Science

* Part-time
† Primary appointment in the School of Medicine and Dentistry
Jennifer Kruschwitz, MS (Rochester)  
*Adjunct Assistant Professor of Optics*

Nicholas N. Kuzma, PhD (Yale)  
*Assistant Professor of Biomedical Engineering and of Imaging Sciences*

Qiang Lin, PhD (Rochester)  
*Assistant Professor of Electrical and Computer Engineering*

Andrei Maximov, PhD (Lebedev Physics Institute of Russia)  
*Adjunct Assistant Professor of Mechanical Engineering and Scientist in the Laboratory for Laser Energetics*

Hitomi Mukaibo, PhD (Waseda University, Japan)  
*Assistant Professor of Chemical Engineering*

Jong-Hoon Nam, PhD (Virginia Tech)  
*Assistant Professor of Mechanical Engineering and of Biomedical Engineering*

†Walter O’Dell, PhD (Johns Hopkins)  
*Assistant Professor of Radiation Oncology and of Biomedical Engineering*

†David J. Pinto, PhD (Pittsburgh)  
*Assistant Professor of Biomedical Engineering and of Neurobiology and Anatomy*

Keith Schneider, PhD (Rochester)  
*Assistant Professor (Research) in the Center for Brain Imaging, in the Center for Visual Science, and of Biomedical Engineering*

†Scott H. Seidman, PhD (Case Western Reserve)  
*Assistant Professor of Biomedical Engineering and of Neurobiology and Anatomy, and in the Center for Visual Science*

Samuel Thurman, PhD (Rochester)  
*Assistant Professor (Research) of Optics*

Nickolas Vamvakas, PhD (Boston)  
*Assistant Professor of Optics*

Muthuramakrishnan Venkitasubramaniam, PhD (Cornell)  
*Assistant Professor of Computer Science*

Ping Zhu, PhD (Rochester)  
*Adjunct Assistant Professor of Mechanical Engineering*

James P. Knauer, PhD (Hawaii)  
*Senior Scientist in the Laboratory for Laser Energetics*

Robert Kremens, PhD (NYU)  
*Scientist in the Laboratory for Laser Energetics*

Samuel Letzring, PhD (Rochester)  
*Senior Scientist in the Laboratory for Laser Energetics*

Svetlana Lukishova, PhD (Moscow Institute of Physics and Technology)  
*Senior Scientist in the Laboratory for Laser Energetics*

Frederic Marshall, PhD (MIT)  
*Senior Scientist in the Laboratory for Laser Energetics*

Patrick McKenty, PhD (Arizona)  
*Senior Scientist in the Laboratory for Laser Energetics*

Michael O. Miller, BS (Rochester)  
*Senior Scientist in the Laboratory for Laser Energetics*

Andrey V. Okishev, PhD (Institute of Fine Mechanics and Optics)  
*Scientist in the Laboratory for Laser Energetics*

Semyon Papernov, PhD (Latvian U. Riga)  
*Scientist in the Laboratory for Laser Energetics*

Sean P. Regan, PhD (Johns Hopkins)  
*Scientist in the Laboratory for Laser Energetics*

Alexander Ryskin, PhD (USSR Academy of Sciences)  
*Scientist in the Laboratory for Laser Energetics*

Angar Schmid, PhD (Tech. U. Vienna)  
*Scientist in the Laboratory for Laser Energetics*

Robert Short, PhD (Wisconsin)  
*Senior Scientist in the Laboratory for Laser Energetics*

Stanley Skupsky, PhD (Chicago)  
*Senior Scientist and Director of Theory in the Laboratory for Laser Energetics*

John M. Soures, PhD (Rochester)  
*Senior Scientist in the Laboratory for Laser Energetics*

Christian Stoeckl, PhD (Technische Hochschule Darmstadt)  
*Scientist in the Laboratory for Laser Energetics*

Charles Verdon, PhD (Arizona)  
*Senior Scientist in the Laboratory for Laser Energetics*

Anatoliy Vorobyev, PhD (Tomsk State University)  
*Senior Scientist in the Institute of Optics*

Barukh Yaakobi, PhD (Hebrew)  
*Senior Scientist in the Laboratory for Laser Energetics*

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* Part-time  
† Primary appointment in the School of Medicine and Dentistry
Biomedical Engineering

Adjunct Associate Professor Borkholder, Gdowski
Adjunct Assistant Professor Jacob

Affiliated with both the Edmund A. Hajim School of Engineering and Applied Sciences and the School of Medicine and Dentistry, the Graduate Program in Biomedical Engineering at the University of Rochester has been designed from the ground up to emphasize the application of engineering skills to biomedical problem solving at both the master’s and doctoral level. Our educational program provides training to ensure a solid foundation in both engineering principles and in biological sciences.

Biomedical engineers can choose from a wide range of careers, from basic research to clinical applications. This is reflected in the diverse talents and interests of the BME faculty, many with affiliations in both engineering and clinical departments. Our research strengths include, but are not limited to, biomedical imaging, neuroengineering, biomedical optics, biomechanics, biomaterials, biomanufacturing, and cell and tissue engineering, among others.

With facilities in both the newly constructed Robert B. Goergen Hall for Biomedical Engineering and Optics and the University of Rochester Medical Center, our graduate program offers state-of-the-art dedicated training laboratories, close individual attention and faculty mentoring, and a growing and welcoming learning community of friends and future colleagues.

Further information about BME-related research at the University of Rochester, including our current admission and program requirements, can be found on the web at www.urmc.rochester.edu/bmc/ or by writing to University of Rochester, Director of Graduate Studies, Department of Biomedical Engineering, Robert B. Goergen Hall, P.O. Box 270168, Rochester, NY 14627-0168.

404. Computational Methods Applied to Biological Systems
Computational methods to solve analytically intractable mathematical problems in biological research. Using MATLAB as a programming language; numerical methods for linear algebra, ODE, and PDE; case studies such as biodynamics of human locomotion, ion channel kinetics, ionic diffusion in cells, and finite element analysis of cells/tissues.

418. Introduction to Neuroengineering

428. Physiological Control Systems
(Same as ChE 432)
The course focuses on the application of control theory to physiological systems. Lectures present modern control theory in the context of physiological systems that utilized feedback mechanisms. Lectures begin with an overview of linear systems analysis including Laplace transforms and transfer functions. The response dynamics of open- and closed-loop systems such as the regulation of cardiac output and level of glucose are discussed. Other topics include stability analysis and identification of physiological control systems.

432. Controlled Release Systems
(Same as ChE 432)
This course is designed to provide students with an understanding of the principles, strategies, and materials used in controlled drug delivery systems.

442. Microbiomechanics
This course covers the application of mechanical principles to biotechnology and to understanding life at its smallest scales. Topics vary with each course offering. Sample topics include force generation by protein polymerization, the mechanisms of bacterial motility, and the separation of biological molecules in porous media.

445. Biomaterials
(Same as MSC 445)
This course provides a background in biomaterials: basic material properties, specifics on ceramics, polymers and metals used in the body, and special topics related to biomaterials including tissue engineering, biological responses to implanted materials, and drug delivery.

451. Biomedical Ultrasound
(Same as ECE 451)
Prerequisite: permission of instructor.
The physical basis for the use of high-frequency sound in medicine (diagnosis, therapy, and surgery) and biology. Acoustic properties of tissues, sound propagation in tissues, including linear processes as well as finite amplitude sound propagation, and the development of shock waves, interactions of ultrasound with gas bodies, leading to the phenomenon of acoustic cavitation, thermal and nonthermal biological effects of ultrasound, ultrasonography, dosimetry, radiation diathermy, thermal therapy, lithotripsy.

452. Medical Imaging—Theory and Implementation
(Same as ECE 452, OPT 452, PHY 462)
Prerequisite: ECE 242.
Physics and implementation of X-ray, ultrasonic, and MR imaging systems. Special attention is given to the Fourier
transform relations and reconstruction algorithms of X-ray and ultrasonic-computed tomography, and MRI.

453. Advanced Biomedical Ultrasound  
(Permission as ECE 453)  
Prerequisites: BME 451 or permission of instructor.

This course investigates the imaging techniques applied in state-of-the-art ultrasound imaging and their theoretical bases. Topics include linear acoustic systems, spatial impulse responses, the k-space formulation, methods of acoustic field calculation, dynamic focusing and apodization, scattering, the statistics of acoustic speckle, speckle correlation, compounding techniques, phase aberration correction, velocity estimation, and flow imaging. A strong emphasis is placed on readings of original sources and student assignments and projects based on realistic acoustic simulations.

454. Principles of Magnetic Resonance Imaging  
This course introduces the principles of MRI and its applications to graduate and undergraduate students. The acquisition and reconstruction of MR images is covered in detail.

455. Translational Biomedical Optics  
This course focuses on the macroscopic biomedical optics techniques (e.g., diffuse optical spectroscopy and tomography, photoacoustic tomography) with high potentials for clinical translation. Students learn the aspects of instrumentation design, analytic and numerical approaches for optical data analysis, and validation of new technologies in the clinical setting.

460. Quantitative Physiology  
A quantitative, model-oriented approach to physiological systems is presented. Topics include muscle and nerve tissue, the cardiovascular system, the respiratory system, the renal system, and a variety of neural systems.

462. Cell and Tissue Engineering  
Prerequisites: BME 260, CHE 225, CHE 243, CHE 244 or permission of instructor.

This course teaches the principles of modern cell and tissue engineering with a focus on understanding and manipulating the interactions between cells and their environment. After a brief overview of Cell and Tissue Engineering, the course covers five areas of the field. These are (1) physiology for tissue engineering; (2) bioreactors and biomolecule production; (3) materials for tissue engineering; (4) cell cultures and bioreactors; and (5) drug delivery and drug discovery. Within each of these topics the emphasis is on analytical skills. Instructors assume knowledge of chemistry, mass transfer, fluid mechanics, thermodynamics, and physiology consistent with the Cell and Tissue Engineering track in BME. In a term project, students must identify a technological need and present orally and in writing a proposal to meet that need.

465. Cell Adhesion  
This course covers quantitative aspects of receptor mediated cell adhesion: kinetic descriptions, role of mechanical force. Types of adhesion molecules are reviewed with an emphasis on inflammation.

467. Models and Simulations of Biomedical Systems  
Prerequisites: BME 221 and 230 or permission of instructor.

This course introduces analytical modeling and computational simulations of systems. Examples include cardiovascular, respiratory, muscle, neural, and population models.

470. Biomedical Microscopy  
This course covers the principles and practice of light microscopy as applied to biological and medical questions. Topics include basic light microscopy, epifluorescence, confocal and multiphoton laser-scanning microscopy, and selected methods such as CARS, FRET, FRAP, FCS, etc.

474. Biomedical Sensors, Circuits, and Interfacing  
Course covers circuits and sensors used to measure physiological systems at an advanced level. Both signal conditioning and sensor characteristics are addressed. Topics include measurement of strain, pressure, flow, temperature, biopotentials, and physical circuit construction. The corequisite laboratory focuses on the practical implementation of electronic devices for biomedical measurements.

483. Bioelastic Mechanics  
(Permission as ME 483)  
Application of engineering mechanics to biological tissues including muscle, soft tissue, cell membranes, and bone. Realistic modeling of biological structures, including the heart, blood vessels, and the skeleton. Experimental and computational methods and material models.

485. Cell and Membrane Mechanics  
Prerequisites: background in solid mechanics, some cell biology is desirable; permission of instructor is required.

The primary focus of this course is on the fundamental science underlying the mechanical behavior of cell membranes, with some additional attention given to the mechanical behavior of leukocytes. The approach is to explore mathematical descriptions of the physical properties of biomembrane structures. Basic aspects of the structure and composition of cell membranes are reviewed as a basis for the mathematical treatments.

486. Finite Elements  
(Permission as ME 441, TME 441)  
This course provides a thorough grounding on the theory and application of linear finite element analysis in solid mechanics and related disciplines. Topics: structural matrix analysis concepts and computational procedures; shape functions and element formulation methods for 1-D, 2-D problems; variational
methods, weighted residual methods, and Galerkin techniques; isoparametric elements; error estimation and convergence; global analysis aspects. Term project and homework require computer implementation of 1-D and 2-D finite element procedures using MATLAB.

**502. Analytic Foundations in Biomedical Engineering**

The goal of this course is to introduce students to a select range of key concepts and methods from engineering and applied mathematics that are common across most subdisciplines of BME and to illustrate by example how these concepts and methods can be applied directly in the study of biological systems and/or for the solving of biological problems. We expect that students completing the course will have acquired basic practical skills to develop novel analytic approaches to biological problems and will be well prepared for subsequent coursework in their chosen discipline.

**511. Cellular and Molecular Foundations**  
*Same as ANA 511*

Cellular and molecular biology principles geared toward graduate students without detailed background in biological sciences.

**513. MR Imaging: From Spins to Brains**  
*Same as BCS 513, NSC 513, PHY 513*  
**Prerequisite:** Graduate-level math course.

This course introduces students to the physics of MR imaging and reviews its application to medical imaging. How the MR technique can take advantage of physiological principles and tissue structure to provide diagnostic image for clinicians and researchers is discussed. Then what can be learned about brain functions through MR imaging is covered. In particular, students are introduced to functional brain imaging and related issues in data analysis. The goal of the class is to provide students with a comprehensive background of the MR imaging technique and its application to medical or research issues.

**515. Neural Control of Behavior**  
*Same as ANA 515*  
**Prerequisite:** NSC 531 or permission of instructor.

This course investigates the neural control of movement beginning with an understanding of muscle properties and mechanisms of contraction. The course continues with an exploration of important conceptual and theoretical issues in the control of movement: the “degrees of freedom” problem and possible solutions, locomotion and central pattern generators, and the roles of cortex and brainstem in motor control.

**589. Writing Proposals in BME**

This course covers the essential aspects of organization and content for writing formal scientific proposals. Open to second-year PhD candidates.

**593. Lab Rotations in BME**

Students rotate in at least three different labs during the first year of graduate study to learn of the diversity of research opportunities for PhD research.
Rochester Center for Biomedical Ultrasound

Director: Diane Dalecki (Biomedical Engineering)
Associate Director: Deborah J. Rubens (Imaging Sciences)

Affiliated University of Rochester departments: anesthesiology, biomedical engineering, biophysics/biochemistry, cardiology, dermatology, earth and environmental sciences, electrical and computer engineering, emergency medicine, imaging sciences, immunology/rheumatology, mechanical engineering, obstetrics and gynecology, pathology, pharmacology and physiology, radiation oncology, urology, and vascular medicine.

The Rochester Center for Biomedical Ultrasound (RCBU), created in 1986, unites professionals from both the medical and engineering communities. The RCBU includes nearly 100 professionals from a diverse selection of departments at the University of Rochester, as well as colleagues from Rochester General Hospital and Rochester Institute of Technology. RCBU laboratories are advancing the use of ultrasound in diagnosis and discovering new applications of ultrasound in medicine and biology. The RCBU does not offer independent degree programs. Rather, students can pursue advanced degrees (MS and PhD) in various departments of engineering and applied sciences with a focus on biomedical ultrasound. RCBU laboratories provide a rich environment for graduate training in biomedical ultrasound, and students have access to state-of-the-art facilities for their research. A wide range of course offerings across multiple disciplines complements the rich environment for research in biomedical ultrasound. The Center sponsors seminars, international workshops, and courses for the advancement of diagnostic and therapeutic ultrasound that are announced to the greater ultrasound community throughout the year. Graduate students can get involved in the Center by indicating an interest in related research, attending the regular Center seminars and workshops, and requesting an assignment as a research assistant as projects become available.

Visit the RCBU website at www.urmc.rochester.edu/rcbu.

Laboratory for Laser Energetics

The Laboratory for Laser Energetics (LLE) is a unique national resource for advanced research and education related to the application of high-power lasers. The Laboratory has the five-fold mission to (1) conduct research in inertial confinement fusion and high-energy-density phenomena; (2) provide education and training at the graduate and undergraduate levels in electrooptics, plasma physics, high-powered lasers, and nuclear fusion technology; (3) develop new technology and materials in support of the national laser-fusion program; (4) conduct basic physics experiments; and (5) operate the National Laser Users Facility.

LLE does not offer any degree programs. Graduate students join the Laboratory by registering in one of the graduate degree programs within the University. Currently, students working at the LLE are enrolled in the Departments of Mechanical, Electrical and Computer, or Chemical Engineering; Physics and Astronomy; Chemistry; Biophysics; or The Institute of Optics.

Self-supported research laboratories are important adjuncts to the academic departments in a relatively small school of engineering. If the research can be successfully integrated with undergraduate and graduate education, such laboratories can compensate for the economies of scale that exist in large universities. They can do much to provide the costly technological infrastructure that is essential for both education and research. The 27 department-based professors, 78 graduate students, and 48 undergraduates involved in the Laboratory’s research program in various ways illustrate this important synergism.

Graduate students join the Laboratory by registering in a doctoral program offered by one of the departments in the Hajim School of Engineering and Applied Sciences or the Department of Physics and Astronomy in the arts and sciences and by indicating a preference for research at the Laboratory. The academic department chosen by the student determines the course and examination requirements for the PhD degree.

The Laboratory also has a small number of postdoctoral appointments available for one- or two-year periods. Candidates for postdoctoral fellowships should apply no later than January of the year in which they seek the post.

Qualified undergraduates enrolled in a degree program offered by the Hajim School of Engineering and Applied Sciences or the Department of Physics and Astronomy are also eligible to participate in the Laboratory’s programs during their junior or senior year. Undergraduate candidates apply directly to the Laboratory’s associate director for academic affairs for appointments as research trainees.
Chemical Engineering

Professors Chen, Chimowitz, Jorné, Tang (Chair), Wu
Associate Professors Anthamatten, Yates, Kelley
Assistant Professors Mukai, Shestopalov
Adjunct Professors *Chang, *Greener, Yang
Adjunct Assistant *Foster
Joint Appointments: Professors Jacobs, Harding, Rothberg, Shapir; Assistant Professor Benoit
Professors Emeriti Eisenberg, Feinberg, Ferron, Saltsburg

Through experimentation, theory, and computation, chemical engineers apply biological, chemical, and physical principles to contemporary problems in biotechnology, materials, energy, and the environment. The chemical engineering faculty, postdoctoral research associates, and graduate students conduct research at the forefront of modern chemical engineering. Research strengths include advanced materials, bioengineering, nanoscale science and engineering, and research applied to energy and environmental issues. The applications of the research are far reaching and examples include new treatments for diseases, optoelectronic materials for flat panel displays, fuel cell development, pollution prevention, and development of new materials to be used in laser fusion. The interdisciplinary nature of chemical engineering research manifests itself in active collaborations with the Departments of Chemistry, Optics, Physics, and Electrical and Computer Engineering; the School of Medicine and Dentistry; and the Laboratory for Laser Energetics.

PhD Program

To educate a new generation of chemical engineers with unique interdisciplinary skills, students earning PhD degrees in chemical engineering are encouraged to select thesis topics falling within materials science, alternative energy, or biotechnology. Students carrying out research in these areas have the opportunity to be associated with a wide range of funded projects that provide thesis topics designed to meet individual interests and career plans. Full-time PhD students receive competitive graduate fellowships or research assistantships comprising an annual stipend plus full coverage of graduate tuition. Normally students begin their graduate studies in the fall semester. The first two semesters are devoted primarily to graduate courses selected in consultation with their thesis advisors. Consistent with the interdisciplinary emphasis, students are encouraged to take courses in chemical engineering and in other science and engineering graduate programs across the campus. The coursework is designed not only to furnish a foundation for thesis research but also to prepare students for a dynamic professional career upon graduation. As part of their educational experience, all PhD students are expected to provide undergraduate teaching assistance during the first two semesters. At the end of the second semester in residence, students take a PhD preliminary examination as a transition from classroom to full-time research, the formal basis for admission to PhD candidacy is a qualifying examination, taken before the third year in residence, in which students defend a written proposal for thesis research. To earn a PhD degree, students must complete a program of study of 90 credit hours (or 60 credit hours beyond the MS degree) consisting of a minimum of 30 credit hours of formal coursework (or 18 hours of formal coursework beyond the MS degree) and the balance of credit hours earned through reading and/or research courses. The formal courses must include three “core” chemical engineering courses as described below. On average it takes five years to complete all the PhD degree requirements, which include successful defense of a dissertation presenting significant technical contributions to the field.

MS Program

The Master of Science degree may be pursued on either a full-time or part-time basis. Graduate students choosing Plan A complete a thesis, while Plan B MS students follow a formal coursework/non-thesis option.

MS Program (Plan A)

All students who pursue the MS degree with thesis (Plan A) are expected to earn 30 hours of credit of which a minimum of 18 and a maximum of 24 hours should be formal coursework acceptable for graduate credit. The balance of credit hours required for the degree is earned through MS reading and/or research courses (CHE 491/495). Satisfactory defense of a written master’s thesis is also required for the degree, independent of satisfactory completion of the research courses (CHE 495).

MS Program (Plan B)

All students who pursue the MS degree without thesis (Plan B) must earn a minimum of 32 credits of coursework acceptable for graduate credit. At least 18 of these credits should be taken from courses within the department. Overall, no more than six credits towards degree may be earned by research and/or reading courses. The additional courses in the Plan B program (over Plan A) are intended to compensate for the elimination of a thesis as a degree requirement. Students earning a Plan B are required to pass a comprehensive oral exam towards the end of their program. This is intended to ensure some breadth in their technical education, consistent with the core course requirements. Students should consult the graduate program administrator when they are ready to schedule this exam.

Note: For both the Plan A and B degree options, at least 12 of the 18 hours of formal course requirement must be at the 400 level or above. The formal courses must also include three “core” chemical engineering courses as described below.

3-2 BS-MS Program

An appealing option for chemical engineering undergraduates at Rochester who enjoy the fundamental aspects of the field and the opportunities of independent research is the department’s 3-2 or BS-MS program. This program leads to both the BS and
the MS degrees in chemical engineering in five years (the BS at the end of the fourth year and the MS at the end of the fifth year). Interested students are encouraged to apply for this program in the spring of their third year so that they will have ample time to integrate the coursework for both degrees into their final two years of study, as well as to initiate the research work required for the MS degree. Students accepted into this program are granted a 75 percent tuition scholarship upon graduate matriculation for the remainder of the MS graduate program of study.

**Professional Master of Science Degree**

The objective of this degree is to provide interested students with an advanced degree in chemical engineering that at its core requires a significant period spent in an industrial setting working on an advanced technical project identified by the industrial sponsor and a department faculty member. The professional MS degree is earned through a combination of advanced coursework and a project report related to the industrial project worked on by the student.

**Degree Requirements**

All students who pursue the professional MS degree with project are expected to earn 30 hours of credit of which at least 18 should be formal coursework acceptable for graduate credit. The balance of credit hours required for the degree is earned through the industrial project performed by the student at the industrial location and evaluated by the faculty advisor in concert with the industrial supervisor. These credits are graded as independent study/research credits.

**Biochemical Engineering Option**

Students in chemical engineering have the option of replacing the MS degree (Plan B) requirements with 32 hours of coursework to include the following specially designed sequence of requirements in biochemical engineering: BIO 408, MBI 445, and CHE 469, plus requirements mentioned for the MS degree (Plan B).

All students choosing the biochemical engineering option must demonstrate competency in the undergraduate prerequisite subject matter including genetics, biochemistry, mathematics, transport phenomena, and separation processes.

**Core Course Requirements**

- Advanced fluid dynamics/transport phenomena (e.g., CHE 441)
- Thermodynamics and statistical mechanics (e.g., CHE 455)
- Applied Mathematics (e.g., CHE 400)

For those students entering without a chemical engineering background, the core course requirement may be obtained by taking two undergraduate courses* in the following areas offered by the department: Thermodynamics (CHE 225), Heat and Mass Transfer (CHE 244), Fluid Dynamics (CHE 243), Separation Processes (CHE 250), and Reactor Design (CHE 231), plus one graduate-level course from the core areas listed above.

All courses carry four credit hours unless otherwise noted.

### CHEMICAL ENGINEERING FUNDAMENTALS

**400. Applied Boundary Value Problems**

This course covers the classical partial differential equations of mathematical physics: the heat equation, the Laplace equation, and the wave equation. The primary technique covered in the course is separation of variables, which leads to solutions in the form of eigenfunction expansions. The topics include Fourier series, separation of variables, Sturm-Liouville theory, unbounded domains and the Fourier transform, spherical coordinates and Legendre's equation, cylindrical coordinates, and Bessel's equation. The software package Mathematica is used extensively. Prior knowledge of Mathematica is helpful but not essential. In the last two weeks of the course, there is a project on an assigned topic. The course includes applications in heat conduction, electrostatics, fluid flow, and acoustics.

**441. Advanced Transport Phenomena**

This course acquaints the student with important topics in advanced transport phenomena (momentum, heat, and mass transport). Topics include laminar and turbulent flow, thermal conductivity and the energy equation, molecular mass transport and diffusion with heterogeneous and homogeneous chemical reactions. Focus is to develop physical understanding of principles discussed and emphasis on chemical engineering applications. In addition to the text, the student is exposed to classic and current literature in the field. (Fall)

**454. Interfacial Engineering**

Lectures on the fundamentals of colloids and interfaces, systems with high interfacial area, and their role in modern processes and products. Topics include interfacial tension, contact angle, adsorption, surfactants, micelles, microemulsions, and colloidal dispersions. Techniques for formation and characterization of interfaces and colloids are reviewed. (Spring)

**455. Thermodynamics and Statistical Mechanics**

The course draws connections between the orderly and chaotic behavior of simple and complex systems, laying the foundations of statistical equilibrium and equilibrium thermodynamics. The different phases of matter (gases, liquids, solid) assumed by bulk classical interacting particles and their transitions are discussed in this approximation. Properties of noninteracting quantal systems are expressed in terms of partition functions, for gases of simple and complex particles. Nonequilibrium statistical behavior of multiparticle systems leads to diffusion and other transport phenomena. (Fall)

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* 200- and 300-level courses carry three rather than four graduate credits.
460. Solar Cells
This course introduces students to the basics of photovoltaic devices: physics of semiconductors, pn junctions, Schottky barriers, processes governing carrier generation, transport and recombination, analysis of solar cell efficiency; crystalline and thin-film solar cells, tandem structures, dye-sensitized and organic solar cells. Students learn about current photovoltaic technologies including manufacturing processes and also the economics of solar cells as an alternative energy source. Critical analysis of recent advances and key publications are a part of the coursework.

464. Biofuels: Biological Approach
An overview of biological science, technologies, and processes relating to biomass as an alternative energy source.

465. Thermochemical Biomass Conversion
Conversion of biomass to liquid fuels and chemical feedstocks traditionally derived from petroleum. Production of jet fuel, gasoline, and diesel fuel via gasification, liquefaction, pyrolysis, aqueous phase reforming, and transesterification of a variety of biomass. Generation of chemical platforms in support of food, drug, pharmaceutical, and polymer industries. Green chemistry and engineering aimed to improve sustainability of chemical conversions of a plethora of key intermediates originating from biomass. Use of environmentally benign solvents—such as ionic liquids, water, and supercritical carbon dioxide—in place of organic solvents. Catalytic chemical reactions with ball milling, microwave irradiation, and sonochemistry using minimum catalysts and solvents while maximizing reaction rates and yields for ease of product isolation and purification. Microreactor technology to maximize heat and mass transfer rates, reaction yields and product selectivities, and to facilitate process control, optimization, and scale-up.

485. Advanced Thermodynamics
Thermodynamic stability theory and its relationship to the first and second laws of thermodynamics. The use of the Legendre function formalism to derive all relevant thermodynamic potentials and the Gibbs-Duhem equation. Introduction to statistical mechanics and its application to molecular modeling of thermodynamic properties for pure components and mixtures. Mean-field theories, equations of state and statistical mechanical perturbation theory with applications to phase and chemical equilibrium calculations. (Spring)

ADVANCED MATERIALS
413. Engineering of Soft Matter
This course provides an overview of several contemporary research topics pertaining to structured organic materials. Lectures focus on intermolecular interactions and the thermodynamics of self-assembly. Additional lectures introduce molecular crystals, polymer crystallinity, liquid crystals, self-assembled monolayers, surfactants, block copolymers, and biomimetic materials. (Spring)

421. Thin-Film Processing
This course covers the fundamentals and techniques involved in making thin films. Gas phase processes such as chemical and physical vapor deposition are emphasized. The advantages and limitations of each technique, and the associated material properties, are discussed. Scientific and engineering fundamentals that are required to better understand these processing techniques are reviewed within the appropriate context. These include gas kinetic theory, vacuum principles, heat and mass transport, and methods for characterizing materials. Contemporary computational modeling techniques are introduced. (Alternate falls)

430. Organic Electronics
Basic optical and electronic processes of organic molecules and polymers. Charge transport and luminescent properties of organic solids. Metal/organic contacts and charge injection. Applications in thin-film organic electronic devices including organic light-emitting diodes, solar cells, photoconductors, and transistors. (Spring)

447. Optics and Liquid Crystals for Chemical Engineering
This course introduces the materials, terminology, effects, and devices used in the field of liquid crystal optics. Basic structures in nematic and cholesteric liquid crystals are discussed and related to optical phenomena like transmittance, absorptions, scattering, birefringence, and selective reflection (the effect seen in scarab beetles and used to protect the Omega laser in LLE from blowing itself up). Two keys for device applications are LC chemical composition and molecular alignment, and these are covered in order to understand the manufacture and operation of polarizers. The basic electro-optics for active devices like EO switches and LC displays are also covered. Other applications explored include mood rings, polarizing pigments for document security, smart windows, and car paint. Chemical engineering graduate students are given enough introductory optics to understand the concepts and applications described in the course. (Alternate springs)

458. Electrochemical Engineering and Fuel Cells
Credit—two hours
The course concentrates on presenting the principles of electrochemistry and electrochemical engineering, and the design considerations for the development of fuel cells capable of satisfying the projected performance of an electric car. The course is expected to prepare students for the challenges of energy conversion and storage and the environment in the twenty-first century. (Fall)

482. Processing Microelectic Device
Credit—two hours
An overview of processes used in the fabrication of microelectronic devices, with emphasis on chemical engineering principles and methods of analysis. Modeling and processing of microelectronic devices. Includes introduction to physics and technology of solid-state devices grade silicon, microlithography, thermal
processing, chemical vapor deposition, etching and ion implantation and damascene processing. (Fall)

486. Polymer Science and Engineering
This course features the science and technology of synthetic macromolecules. Topics include polymerization reactions, structure and properties of semicrystalline and amorphous polymers, characterization of structure and properties, structure-property relationships in polymers, and application of polymeric materials. (Fall)

487. Polymer Rheology and Processing
The unique transport and equilibrium properties of organic polymers are studied and applied, with basic chemical engineering principles to the analysis of polymer processing. Topics include fluid flow and heat transfer in polymer systems, rheological equations of polymer systems, rheological equations of state, and the study of fabricating operations, such as calendaring, extrusion, and injection molding. (Alternate springs)

BIOTECHNOLOGY

462. Cell and Tissue Engineering
This course teaches the principles of modern cell and tissue engineering with a focus on understanding and manipulating the interactions between cells and their environment. After a brief overview of Cell and Tissue Engineering, the course covers five areas of the field. In a term project, graduate students must identify a technological need and present orally and in writing a proposal to meet the need. (Spring)

469. Biotechnology and Bioengineering
The life science and engineering principles underlying biotechnology processes; established biotechnology processes including microbial and enzyme conversions, metabolic pathways, and fermentation kinetics; tools for biotechnology development including the recombinant DNA and monoclonal antibody techniques; emerging areas at the forefront of biotechnology, including immune technology and tissue and organ cultures. (Spring)

492. BioInterfaces
The course focuses on interfacial phenomena in hybrid bio-inorganic systems. The goal of the course is to increase the understanding of interactions between biomolecules and surfaces. The course aims at investigating the behavior of complex macromolecular systems at material interfaces and the importance of such systems in the fields of biology, biotechnology, diagnostics, and medicine. The first part of the course focuses on mechanisms of interactions between biomolecules and surfaces. The second part focuses on the characterization of physical, chemical, and morphological properties of biointerfaces.

507. Advanced Genetics and Genomics
This course offers in-depth discussions of theoretical concepts and experimental strategies in genetics and genomics. Lectures cover genetically tractable model organisms, including yeast, Drosophila, Caenorhabditis elegans (a nematode), mouse, and human and their analyses from gene to genome and systems level. Examples of the particular questions that can be addressed with advantage in each genetic model are presented, and the special genetic approaches feasible in these respective systems are emphasized. The course builds upon a strong prior background in Mendelian and molecular genetics. Topics covered include the genetic basis of pattern formation, cell-fate determination, control of cell function, structure-function relationships in macromolecules, and searching for genes important in human health. Additional topics incorporated recently into the course include genome structure and evolution, small RNAs and mobile genetic elements, epigenetics and genomics, proteomics, and other studies at the whole genome level. (Fall)

ADDITIONAL COURSES
Chemical engineering graduate students are encouraged to take courses outside the department as part of their effort to build a solid foundation for thesis research and to prepare themselves for a dynamic professional career. Some examples are as follows:

CHM 424. Physical Methods in Inorganic Chemistry

CHM 435. Organic Reactions

CHM 451. Quantum Chemistry I

ME 451. Crystallography and X-ray Diffraction
Computer Science

Professors Allen, Brown, Dwarkadas, Hemaspaandra, Kautz (Chair), Luo, Schubert, Scott
Associate Professors Ding, Nelson, Seiferas, Shen
Assistant Professors Bigham, Gildea, Stefankovic, Venkitasubramaniam
Joint Appointments: Professors Jacobs, Knill; Associate Professors Heinzelman, Huang; Assistant Professors Ipek, Jaeger
Adjunct Instructors Gallagher, Koomen, Raqueno, Singhl
Lecturers Pulvicki
Scientists Ferguson, Swift

The Department of Computer Science offers a program of study leading to the degrees of Doctor of Philosophy and Master of Science. Only full-time students are admitted to the PhD program, which is designed to require at least four years of study, with the fourth and usually a fifth year devoted to dissertation research and writing. PhD students receive financial support as research assistants (or are fellowship recipients). They are required to serve as teaching assistants for three semesters. PhD students must pass the comprehensive exams at the end of the first year. The master’s degree is offered to those passing with an appropriate level of performance. Admission to PhD candidacy requires a higher performance level. By the end of the third year, each candidate must pass a qualifying examination in the area of thesis research.

Students may also pursue a terminal/professional MS degree (Plan B) on a part-time basis. A “professional master’s” is typically an MS degree pursued on a part-time basis (generally within five years) by a student employed in local industry. A 3-2 program is offered to University of Rochester undergraduates. Financial support is not available for the MS programs.

MS students must pass a comprehensive examination (or essay), typically in the last semester before graduation.

The only required course for PhD students is CSC 400. For MS students, CSC 400 is optional, at the discretion of the instructor. Credit for courses at the 200- or 300 level is three hours, and credit for research internship courses is one hour. All other courses carry four credit hours except as noted. In addition to the courses listed, the department typically offers two or three graduate-level courses in specialized topics that are announced shortly before the start of the semester.

400. Problem Seminar

An introduction to the technical, social, economic, and political aspects of graduate education in computer science at Rochester. Class meetings consist primarily of group discussions and presentations that focus on a broad range of topics, and are intended to improve the critical analysis, technical writing, presentation, and problem-solving skills of students. Both class discussions and written assignments are drawn from material presented in other first-year graduate courses offered within the department. The course also offers a forum for individual department faculty members to discuss their research interests and recent results. Satisfactory performance is required of all first-year computer science graduate students.

444. Logical Foundations of Artificial Intelligence
The logical foundations of AI including first-order logic, search, knowledge representation, planning, and probability and decision theory.

446. Mathematical Foundations of Artificial Intelligence
The mathematical foundations of robotics and vision applications in AI.

447. Natural Language Processing
Constructing computer programs that understand natural language. Topics include parsing, semantic analysis, and knowledge representation. (Alternating years with 448.)

448. Statistical Speech and Language Processing
An introduction to statistical natural language processing and automatic speech recognition techniques. This course presents the theory and practice behind the recently developed language processing technologies that enable applications such as speech-driven dictation systems, document search engines (e.g., finding web pages), and automatic machine translation. (Alternating years with 447.)

449. Machine Vision
Fundamentals of computer vision, including image formation, elements of human vision, low-level image processing, and pattern recognition techniques.

453. Dynamic Languages and Software Development
Concepts, principles, and practices of dynamic programming languages and modern software design. Advanced techniques in procedural, functional, and object-oriented programming; composition of functions, objects, and modules; design patterns; software process and agile methods; tools for collaborative software development; and select topics in mobile and online software development.

455. Software Analysis and Improvement
The automation of programming itself—how much a program can understand and improve other programs. Combines fundamental principles and (hands-on) practical applications.

456. Operating Systems
Principles of operating system design, explored within the practical context of traditional, embedded, distributed, and real-time operating systems. Topics include device management, process management, scheduling, synchronization principles, memory management and virtual memory, file management and remote files, protection and security, fault tolerance, networks, and distributed computing.

457. Computer Networks
Introduction to computer networks and computer communication: architecture and protocols. Design of protocols for error

458. Parallel and Distributed Systems
Principles of parallel and distributed systems, and the associated implementation and performance issues. Topics include programming interfaces to parallel and distributed computing, interprocess communication, synchronization, and consistency models, fault tolerance and reliability, distributed process management, distributed file systems, multiprocessor architectures, parallel program optimization, and parallelizing compilers.

460. Topics in Natural Language Dialog Systems
This course examines recent research in computational linguistics and artificial intelligence on natural dialog systems. Students take turns leading the discussion of current research papers. Graduates taking the course may have additional readings or assignments.

481. Cryptography
The modern study of cryptography investigates techniques for facilitating interactions between distrustful entities. With the advent of large-scale, networked systems such as the Internet, such techniques have become indispensable—enabling, for instance, electronic voting, privacy-preserving auctions, internet banking, satellite radio/television, and more.

484. Advanced Algorithms
Advanced study of design and analysis of algorithms. Topics typically include growth of functions; recurrences; probabilistic analysis and randomized algorithms; maximum flow; sorting networks; expander graphs; matrix operations; linear programming; discrete Fourier transform; number-theoretic algorithms; string matching; computational geometry; NP-completeness; approximation algorithms.

486. Computational Complexity
The difference between computable and uncomputable problems and between feasible and infeasible problems. Regarding the latter, what properties of a problem make it computationally simple? What properties of a problem may preclude its having efficient algorithms? How computationally hard are problems? Complete sets and low information content; P=NP?; unambiguous computation, one-way functions, and cryptography; reductions relating the complexity of problems; complexity classes, and hierarchies.

487. Randomized, Parallel, and Other Advanced Modes of Computation
Advanced modes of computation such as probabilistic computation, counting-based computation, semi-feasible computation, nondeterminism, computation trees, and parallel access.

490. Supervised Teaching
Credit—two hours
Teaching assistantship to fulfill 3-2 master’s program requirement.

491. Advanced Readings in Computer Science
Credit to be arranged
Reading course at the master’s level.

494. Advanced Research Internship in Computer Science
Prerequisite: consent of the department.
Credit—one hour
Master’s-level research internship with sponsoring employers, usually taken during the summer term and lasting three–four months.

495. Advanced Research in Computer Science
Credit to be arranged
Individual research at the master’s level.

509. Topics in Programming Systems
Intensive study of a currently active research topic.

512. Computational Methods in Cognitive Science
Credit—three hours
Mathematical/computational models of visual perception, decision making, learning, and movement control. The objective is to develop technical knowledge and skills needed to formulate, evaluate, and understand such models.

529. Topics in Programming Languages
Intensive study of a currently active research topic.

549. Topics in Artificial Intelligence
Intensive study of a currently active research topic.

559. Topics in Cognitive Science
Intensive study of a currently active research topic.

571–577. Seminars
Credit—one to four hours
Discussions of current literature and research. Seminars can be arranged to suit interests and demands.

571. Seminar in Cognitive Science
572. Seminar in Programming Languages
573. Seminar in Programming Systems
574. Seminar in Theory of Computation
575. Seminar in Numerical Analysis
576. Seminar in Applications of Computer Science
577. Seminar in Artificial Intelligence

589. Topics in Theory of Computation
   Intensive study of a currently active research topic.

591. PhD Readings in Computer Science
   Credit to be arranged
   Reading course at the PhD level.

594. PhD Research Internship in Computer Science
   Prerequisite: permission of the department.
   Credit—one hour
   PhD-level research internship with sponsoring employers, usually taken during the summer term and lasting three–four months.

595. PhD Research in Computer Science
   Credit to be arranged
   Individual research at the PhD level.

**Electrical and Computer Engineering**

Professors Bocko (Chair), Donaldson, Friedman, Hsiang, Jones, Parker, Sobolewski, Waag
Associate Professors Ampadu, Heinzelman, Huang, Mottley, Sharma, Wu
Assistant Professors Dery, Doyley, Ignjatovic, Ipek, Lin, Yosoughi
Joint Appointments: Professors Dwarkadas, Fienup, Headlam, Ning; Associate Professors Coudere, Dalecki; Assistant Professors DeLouise, Jacob, McAleavey
Adjunct and Visiting Faculty Appointments: Albonesi, Blackstock, Derefinko
Scientists Astheimer, Hah, Seyedi, Soyata, Velikic
Professor Emeritus Carstensen

The Department of Electrical and Computer Engineering offers graduate work leading to the MS and PhD degrees. The faculty emphasizes graduate research and instruction in the general areas of electronics and computer systems, optoelectronics, silicon nanoscience, signal/image/audio processing and biomedical imaging, superconductivity and solid state, sensors, networks, electromechanical systems, and bioinformatics. The faculty serve as directors or key researchers in leading national centers such as the Center for Biomedical Ultrasound, the Center for Future Health, the Center for Electronic Imaging Systems, and the Laboratory for Laser Energetics. Outstanding opportunities for graduate student research and training are available at these on-campus centers and in the other departmental laboratories.

Selected examples of current research in several of these areas include digital image and image sequence processing, pattern recognition, medical imaging; fast relaxation processes in semiconductors and in superconductors by use of femtosecond laser pulses; nanoscale silicon for optoelectronics and biosensing; advanced ULSI and VLSI synchronization and design; analysis and design of computer-based design tools for enhancing productivity of analog and digital circuit designers; semiconductor device modeling; radio frequency integrated circuits, analog to digital converters, image sensors, wireless communications; biomedical instrumentation; protocols for wireless ad hoc networks; sound propagation in tissue with applications to diagnosis, therapy, and surgery; quantum electrical systems; microfluidics; audio and music signal processing.

Applicants for graduate study are expected to have performed well in undergraduate programs leading to the BS in electrical and computer engineering or in a related field such as one of the other engineering disciplines or a scientific discipline such as physics, mathematics, or computer science. Students with interests in interdisciplinary work related to electrical and computer engineering usually will find that those interests can be accommodated within the departmental degree requirements.

The programs of graduate study are intended to serve the needs of students who terminate studies at the MS level as well as the needs of students who plan to pursue research at the PhD
level. In addition to the specific degree requirements detailed below, all full-time graduate students are required to participate each semester while in residence in the teaching and/or research programs of the department. For at least one year (two semesters), this teaching experience will involve a maximum of 15 hours total time per week. The teaching will be limited to lecturing in problem sessions or recitations or laboratory, supervising laboratory, or grading homework and laboratory reports. Advanced graduate students who are seeking to prepare for careers as professors and qualify for the rank of instructor may be assigned regular classroom duties. Research is supervised by members of the faculty and often, though not necessarily, forms the basis for the master’s thesis or doctoral dissertation.

All graduate students are expected to perform well in their academic coursework. A grade below B– is considered substandard. Two grades below B– may be grounds for dismissal from the graduate program.

**MS Program**

The program of study for the Master of Science degree involves at least 30 credit hours of graduate study. There are two options for Master of Science study: Plan A candidates for the Master of Science degree write a master’s thesis. Their program should include at least 6 but no more than 12 credit hours of research in their 30-hour program. Plan B candidates are required to take a comprehensive master’s examination and their program of study may contain up to 6 credit hours of research and directed reading.

Every MS degree candidate (including those who are on their way to a PhD degree) must declare a concentration of study in one of the research focus areas of our department. Concentrations are organized as three-course sequences. The goal is to provide depth in at least one area, as opposed to a random sampling of courses, with the expectation that students should be able to follow the current research literature in at least one research concentration upon graduation. The areas of concentration are Signal/Image Processing, Biomedical/Ultrasound, Solid-State Electronics, Optoelectronics, VLSI/IC Microelectronics Design, Computer Design, Musical Acoustics and Signal Processing, Communications, and Fields and Waves. For a list of approved courses for the successful completion of each concentration, refer to the electrical and computer engineering department curriculum guide or your advisor.

In addition, at least 24 credit hours must be at the 400 level or higher and at least 12 of these must be in electrical and computer engineering, exclusive of research or reading courses. Furthermore, at least 18 credit hours of graduate study must be earned in electrical and computer engineering courses numbered at the 200 level or higher. (No more than two 200- or 300-level courses are permitted in the overall program.) To be successful in the graduate program, the student must have a strong background in mathematics. An electrical and computer engineering faculty member should be consulted if such a deficiency is perceived, and appropriate coursework should be identified to build competency before proceeding with the formal program of study.

**THE MS EXAM**

All Plan B (non-thesis option) full-time, part-time, and 3-2 MS students must pass an MS exam. The exam must be conducted by a committee of no less than two ECE faculty members. The Plan A (thesis option) exam committee must contain a member from an external department. It is the responsibility of each MS student to work closely with his or her advisor in selecting a committee. The Graduate Committee can assist with this, if need be. The MS exam committee will decide on the form of the MS exam for each student. The MS exam is an exit exam, that is, students should plan on taking it toward the end of their study. The deadlines for completion of the Plan A and Plan B final examination requirements—oral, written, or essay—for each degree conferral date are listed in the “Graduate Calendar for the College.” Plan A candidates may not defend their thesis until all other degree requirements are completed.

PhD students who wish to receive an MS degree can satisfy the MS exam requirement by completing Parts 1 and 2 of the PhD comprehensive examination.

Students should notify the department’s Graduate Coordinator when they are beginning to plan for their exit exam.

**PhD Program**

The PhD degree requires 90 credit hours of graduate study (60 credit hours beyond the master’s degree), including 45–50 credits of coursework. Students are encouraged to begin research early in their programs. The comprehensive examination, taken during the first year of study, is a requirement for continuation in the PhD program.

All doctoral students must pass a PhD qualifying examination and submit a satisfactory written PhD thesis proposal in their third year of full-time graduate study. Students who have passed the PhD qualifying examination are assisted in matters pertaining to their thesis research by a faculty thesis advisory committee. The research advisor serves as chair. The committee meets with the student at least once each year.

**I. COMPUTERS AND COMPUTATION**

**401. Advanced Computer Architecture**

*Prerequisite: ECE 200 or equivalent.*


**402. Advanced Topics in Memory Systems**

*Prerequisites: CSC 252; ECE 201/401 or permission of the instructor.*

Advanced topics in the organization, architecture, and implementation of modern memory subsystems. Topics include power, performance, reliability, and QoS issues in DRAM memory systems and Flash-based SSDs; high-performance memory controllers and interfaces; memory system design for data centers and enterprise systems; and an introduction to emerging resistive memory technologies. The course has a significant
In this course, advanced GPU parallel programming techniques are taught that permit extremely compute-intensive applications to be run in real time on a cloud-based GPU cluster. These applications demand 1000 to 10000 more compute power than a single CPU (or even a GPU) can provide, making it necessary to utilize the cloud for computation. An additional layer of complexity is introduced into the computational model when real-time response is required. Students are exposed not only to the intricacies of running such compute-intensive applications through high-latency (and potentially unpredictable) communications links.

### 443. Mobile Communications

This course explores mobile wireless communications with emphasis on physical layer issues. The course begins with a brief review of current mobile wireless systems and standards, then characterizes the mobile radio channels (path loss, shadowing, multipath fading effects, frequency selective, and time dispersive channels). The course considers the performance of practical digital modulation schemes under wireless channel impairments and investigates transmitter and receiver design techniques that will improve the performance. The design strategies that are covered include adaptive modulation, diversity techniques (time, frequency, and spatial diversity), equalization, multicarrier modulation (OFDM), spread spectrum (CDMA), multiple transmit and receive antennas (MIMO, spatial multiplexing, space-time coding). The course concludes with the study of multiuser wireless systems and multiple access schemes.

### II. ELECTRONICS AND SOLID STATE

#### 420. Intro to Solid State

**Prerequisite: ECE 221 or equivalent.**

Basic theory and phenomena of solid-state physics, with applications to metals, semiconductors, superconductors, and magnets. A term paper is required for graduate credit.

#### 423. Semiconductor Devices

**Prerequisite: permission of instructor.**


#### 425. Superconductivity and the Josephson Effect

**Prerequisite: permission of instructor.**

Introduction to superconductivity, electron tunneling, and properties of barriers between superconductors, including the DC and AC Josephson effects, superconducting digital and analog devices.

#### 427. Electric Power: Conversion, Transmission, and Consumption

**Prerequisite: seniors and graduate students who possess some background in either thermodynamics or AC circuits.**

The objective of this course is to make engineering and physical science majors conversant in the important elements of electric power, from conversion to consumption. Students learn how the principal sources of energy—coal, natural gas, impounded water (hydroelectric), and fissile materials—are exploited to create electric power, how it is distributed through the grid, and finally how it is consumed. To assure that students gain a proper appreciation for the factors that determine the real cost of electricity per kilowatt-hour, the subject is treated in a highly quantitative way. The goal will be to provide students with the information and tools they need for informed analysis of the true prospects...
and technological challenges of new energy sources, such as biomass, wind power, and oil shale; and for assessment of the opportunities to improve distribution and usage efficiency through a Smart Grid.

435. Introduction to Optoelectronics
Prerequisites: ECE 221, 230, or equivalent.

Introduction to fundamentals of wave propagation in materials, waveguides and fibers, generation, modulation and detection of light using semiconductor devices, and elements of optocommunication systems.

436. Physics and Application of Nanophotonic and Nanomechanical Devices
Prerequisite: This class is designed primarily for graduate students. It may be suitable for senior undergraduates if they have required basic knowledge.


461. Intro to VLSI
Prerequisites: ECE 221, 112.

Issues in digital integrated circuit design. The devices. CMOS inverter. Combinational logic gates in CMOS. Designing sequential logic circuits. Designing arithmetic building blocks. Timing issues in digital circuits. Memories and array structures. Design verification and testing. Design projects using computer-aided design tools; SPICE, MAGIC, IRRISUM, OCTTOOLS. Requires more advanced design projects and design aids or tools. Study of current technical literature is required.

462. Advanced CMOS VLSI Design
Prerequisite: ECE 261 or 222.

Review of CMOS subsystem design. Team project on complex digital systems, such as a simple microprocessor, a self-timed multiplier, or a digital filter. Project design requirements include architectural design, logic and timing verification, layout design, and test pattern generation. The resulting VLSI chips may be fabricated.

464. Fundamentals of VLSI Testing
Prerequisite: ECE 261/461 or permission of instructor.

Design and testing of digital and mixed-signal VLSI/ULSI systems. Reliability issues of digital and mixed-signal systems-on-chip. Testing algorithms, design-for-testability (DFT) and design-for-repair (DFR) strategies. Fault modeling, fault simulation, automatic test generation, data compaction, and pseudo-random technologies; built-in self-test, error detection and data correction in digital design and testing, use of CAT (computer-automated testing) tools for DAT.

465. Performance Issues in VLSI/IC Design and Analysis
Prerequisite: permission of instructor.

Primary and recent research in the fields of high-performance digital and analog VLSI design and analysis. Provides background and insight into some of the more active performance-related research topics of the field such as CMOS design techniques, speed/area/power tradeoffs in CMOS circuits, low-power design, RLC interconnect, synchronization and clock distribution, pipelining/retiming, and many other areas.

466. RF and Microwave Integrated Circuits
Prerequisites: ECE 222, 230 or equivalent. Permission of instructor.

This course involves the analysis and design of radio-frequency (RF) and microwave-integrated circuits at the transistor level. The course begins with a review of electromagnetics and transmission line theory. Several concepts and techniques are introduced, including Smith chart, s-parameters, and EM simulation. Discussion of RLC circuits; high-frequency narrow-band amplifiers; wideband amplifiers. Examination of the issue of noise with the design example of low-noise amplifiers (LNA) and nonlinear circuits with examples of mixers and RF power amplifiers. A study of oscillators and phase noise is followed by the introduction of phase-locked loops (PLL) and frequency synthesizers and concludes with an overview of transceiver architectures. The course emphasizes the development of both circuit design intuition and analytical skills. There are biweekly design labs and a term project using industry-standard EDA tools (ADS, Asitic).

467. Advanced Analog Integrated Circuit Design
Prerequisite: ECE 113, 221.

Analysis and design of analog CMOS integrated circuits. MOS and bipolar device structures and models. Modern opamp design with noise, offset, and distortion analysis, feedback, frequency compensation, and stability. Current mirrors and bandgap references. Sampling devices and structures. Switched-capacitor filters and other digital and digital-to-analog converters. Requires more advanced design projects and use of design aids or tools. Includes material on CAD tools for analog design, including simulation and synthesis.

468. Advanced Analog CMOS Integrated Circuit Design II
Prerequisite: ECE 113, 221, 222, 246/446, 467.

This course discusses the circuitry, algorithms, and architectures used in analog and mixed-mode CMOS integrated circuits. The following topics are discussed: (1) Switched-capacitor (SC) elements, stages, filters. (2) Other SC circuits: S/H stages, comparators, amplifiers, PGAs, oscillators, modulators, voltage boosters and dividers, etc. (3) Non-ideal effects in SC circuits and correction techniques and low-voltage SC design. (4) Switched-current (SI) circuits. (5) CMOS data converters, Nyquist-rate data converter fundamentals, SC and SI implementations of DACs and ADCs. (6) Oversampling (delta-sigma) data converters, fundamentals and implementations. (7) Continuous-time filters based on Gm-C and MOSFET-C schemes, self-tuning techniques.
469. High-Speed Integrated Electronics

An introduction course for state-of-the-art integrated electronics in high-speed and wideband applications, which spans the fields of wireless communications, computing, fiber optics, and instrumentation. The course begins with an overview of high-speed semiconductor technologies (CMOS, SiGe, SOI, GaAs, InP, etc.) and devices (MOSFET, MESFET, HEMT, HBT, and tunneling diodes), followed by discussion of device characterization and technology optimization for circuit performance. The second part of the course focuses on the design of wideband and high-power amplifiers, which includes discussions on feedback, impedance matching, distributed amplifiers, power combining, and switching power amplifiers. The third part of the course involves the design of high-speed phase-locked and delay-locked loops (PLL and DLL). After a review of PLL basics, building blocks are discussed: VCO, frequency divider, phase detector, and loop filter. The course also analyzes PLL performance, in particular phase noise, jitter, and dynamic performance and how to improve them. Two important applications, frequency synthesis and clock recovery, serve as the examples in the discussion. Each part of the course also includes related simulation methods and measurement techniques. The course emphasizes the understanding of basic circuit operation and the development of circuit design intuition.

520. Spin-Based Electronics

Intended for students who are interested in research frontiers of future electronic technologies. The course begins with an introduction to the basic physics of magnetism and of quantum mechanical spin. Then covers aspects of spin transport with emphasis on spin diffusion in semiconductors. The second part of the course is comprised of student and lecturer presentations of selected spintronics topics, which may include spin transistors, magnetic random access memristors, spin-based logic paradigms, spin-based lasers and light-emitting diodes, magnetic semiconductors, and devices (MOSFET, MESFET, HEMT, HBT, and tunneling diodes), followed by discussion of device characterization and technology optimization for circuit performance. The second part of the course focuses on the design of wideband and high-power amplifiers, which includes discussions on feedback, impedance matching, distributed amplifiers, power combining, and switching power amplifiers. The third part of the course involves the design of high-speed phase-locked and delay-locked loops (PLL and DLL). After a review of PLL basics, building blocks are discussed: VCO, frequency divider, phase detector, and loop filter. The course also analyzes PLL performance, in particular phase noise, jitter, and dynamic performance and how to improve them. Two important applications, frequency synthesis and clock recovery, serve as the examples in the discussion. Each part of the course also includes related simulation methods and measurement techniques. The course emphasizes the understanding of basic circuit operation and the development of circuit design intuition.

432. Fundamentals of Acoustic Waves

Prerequisites: MTH 164 and PHY 121.

Introduction to acoustic wave propagation. Topics include acoustic wave equation; energy and momentum transmission through infinite fluid media; reflection and transmission at boundaries; radiation from points, spheres, and pistons; plane and spherical wave propagation; diffraction and beam forming; scattering.

440. Introduction to Random Processes

Prerequisites: ECE 242 or equivalent.

An introduction to random signals and noise in linear systems. This knowledge proves useful in the design and analysis of communication systems and signal processing. Review of selected topics in probability theory, random variables, random vectors, random sequences (random walk, Martingales, ARMA model, Markov chains), random processes (Poisson process, Gaussian process, Wiener process, Markov process), stationary and cyclostationary processes, random process inputs to linear systems, ergodicity, filtering, linear estimation, bandlimited and bandpass processes.

441. Detection and Estimation Theory

Prerequisite: ECE 440, 446 or equivalent, or permission of instructor.

Classical detection and estimation theory (binary hypothesis tests, M hypothesis, Bayes estimation, maximum likelihood estimation), minimum variance unbiased estimators, Cramer-Rao lower bound, best line at unbiased estimators, least squares estimation, applications to detection of signals in noise and estimation of signal parameters. The role of signal design in Radar, Sonar, and wireless communications is discussed.

443. Mobile Communications

This course covers mobile wireless communications with emphasis on physical layer issues. The course begins with a brief review of current mobile wireless systems and standards. Then characterizes the mobile radio channels (path loss, shadowing, multipath fading effects, frequency selective, and time dispersive channels). Considered next are the performance of practical digital modulation schemes under wireless channel impairments and the investigation of transmitter and receiver design techniques that will improve the performance. The design strategies that are covered include adaptive modulation, diversity techniques (time, frequency, and spatial diversity), equalization, multichannel modulation (OFDM), spread spectrum (CDMA), multiple transmit and receive antennas (MIMO, spatial multiplexing, space-time coding). The course concludes with studying multiuser wireless systems and multiple access schemes.
444. Digital Communications
Prerequisites: ECE 242 and 450 or permission of the instructor.

Digital communication system elements, characterization and representation of communication signals and systems. Digital transmission, binary and M-ary modulation schemes, demodulation and detection, coherent and incoherent demodulators, error performance. Channel capacity, mutual information, simple discrete channels, and the AWGN channel. Basics of channel coding and error correction codes.

445. Wireless Communications
Prerequisite: ECE 242 or permission of instructor.

This course teaches the underlying concepts behind traditional cellular radio and wireless data networks (e.g., channel coding, medium-access) as well as design trade-offs among RF bandwidth, transmitter and receiver power and cost, and system performance. This course provides an in-depth look at modern cellular systems, wireless local area and personal area networks, ad-hoc data networks, and sensor networks. Topics include medium access control, routing, flow control, and cross-layer architectures. Issues such as quality of service (QoS), energy conservation, reliability and mobility management are discussed. Students are required to complete a semester-long research project related to the theme of this course.

446. Digital Signal Processing
Prerequisite: ECE 241.

This course begins with a review of discrete-time signals and systems. Following this, the course covers topics related to the analysis and design of discrete-time signals and systems, including: difference equations, discrete-time filtering, z-transforms, A/D and D/A conversions, multirate signal processing, FIR and IIR filter design, the Discrete Fourier Transform (DFT), circular convolution, Fast Fourier Transform (FFT) algorithms, windowing, and classical spectral analysis.

447. Digital Image Processing
Prerequisites: ECE 242, 440, 446 are recommended or permission of instructor.

(1) Digital image fundamentals (visual perception, image sensing and acquisition, image sampling and quantization, basic relationships between pixels). (2) Intensity transformation and spatial filtering (basic intensity transformation functions, histogram processing, fundamental of spatial filtering, smoothing filters, sharpening filters, fuzzy techniques for intensity transformations, and spatial filtering). (3) Filtering the frequency domain (sampling and the Fourier transform, discrete Fourier transform of one and two variables, image smoothing using frequency domain filters, image sharpening using Fourier domain filters). (4) Image restoration and reconstruction (restoration in the presence of noise, periodic noise reduction by frequency domain filtering, estimating degradation function, inverse filtering, constrained least squares filtering, image reconstruction from projections). (5) Multiresolution processing (multiresolution expansions, wavelet transforms). (6) Morphological image processing (erosion and dilation, grayscale morphology). (7) Image segmentation (thresholding, region-based segmentation, morphology watersheds).

450. Information Theory
Prerequisite: MTH 201.

Entropy, relative entropy, mutual information, asymptotic equipartition property, data compression, channel capacity, joint source channel coding theorem, Gaussian channels, rate distortion theory, selected applications.

452. Medical Imaging—Theory and Implementation
Prerequisite: ECE 242.

Physics and implementation of X-ray, ultrasonic, and MR imaging systems. Special attention is given to the Fourier transform relations and reconstruction algorithms of X-ray and ultrasonic-computed tomography, and MRI.

V. MUSICAL ACOUSTICS

433. Musical Acoustics
Prerequisite: differential equations and multivariable calculus, physics.

An early graduate or advanced undergraduate course on the engineering aspects of acoustics. Review of oscillators, vibratory motion, the acoustics wave equation, reflection and transmission, and radiation and reception of acoustic waves. Additional topics as time and interests allow, such as resonators, hearing and speech, and architectural and environmental acoustics.

446. Digital Signal Processing
Prerequisite: ECE 241.

This course begins with a review of discrete-time signals and systems. Following this, the course covers topics related to the analysis and design of discrete-time signals and systems, including difference equations, discrete-time filtering, z-transforms, A/D and D/A conversions, multirate signal processing, FIR and IIR filter design, the Discrete Fourier Transform (DFT), circular convolution, Fast Fourier Transform (FFT) algorithms, windowing, and classical spectral analysis.

471. Computational Music

Fundamentals of computational music including selected topics in modern music theory and music representation, encoding of music information by computers, musical sound representation and compression, automated music transcription, human-computer music interfaces, and music informatics.

472. Topics in Musical Sound Synthesis and Processing

Acoustics and digital signal processing techniques applied to the analysis and synthesis of musical sound. Topics include sampling, quantization and audio quality metrics, time-frequency analysis and sound representations, audio filter design and implementation, musical sound synthesis techniques including spectral-based synthesis, and physical modeling. Additional special topics based on class interests.
479. Theory and Practice in Audio Recording and Processing
This course is designed to teach aspects of audio recording techniques to non-music majors. The weekly sessions include hands-on introductions to microphone techniques, recording hardware and software, digital editing, room acoustics, and mixing and mastering. The course assumes some technical knowledge of signal processing (FFT, dB, etc.), but emphasizes the musical aspects of the recording process. Evaluation is made on the basis of class participation and a final project, which could be a recording session of an RC group or a research paper on some topic related to contemporary recording and sound.

VI. SPECIAL TOPICS

491. Reading Course in Electrical and Computer Engineering (M.S.)
Credit to be arranged
Supervised reading on topics beyond those available in existing courses or on specialized topics.

492. Special Topics
For a current listing of these courses, please view the departmental Web site or call the electrical and computer engineering graduate office at (585) 275-5719.

493. Master’s Essay
Please see the faculty advisor or Graduate Coordinator for more information regarding this option.

494. Master’s Research Internship

495. Research in Electrical and Computer Engineering (MS)
Credit to be arranged

496. Special Projects Course in Electrical and Computer Engineering (MS)
Credit to be arranged

591. Reading Course in Electrical and Computer Engineering (PhD)
Credit to be arranged
Supervised reading on topics beyond those available in existing courses or on specialized topics.

594. PhD Research Internship

595. Research in Electrical and Computer Engineering (PhD)
Credit to be arranged

Materials Science

Professors Bigelow, Bocko, Boyd, Burns, Chen, Chimowitz, Conwell, Dewhurst, Donaldson, Funkenbusch, Jacobs, T. Jones, Krauss (Chair), Lambropoulos, J. Li, B. L. Miller, Prezhdo, Quesnel, Rolland, Rothberg, Sobolewski, Tang, Waugh, Wicks, Wu
Associate Professors Anthamatten, Awad, Guo, McGrath, M. Z. Yates
Assistant Professors Benoit, DeLouise, Dery, Grossfield, Mukaiho, Nilsson, Shestopalov

Materials science deals with the creation, understanding, and use of novel materials for advanced technologies. Specifically, synthesis and processing are used to create the molecular, supramolecular, nanoscale, and microscopic structures required to achieve desired properties. Understanding of new materials is acquired through theoretical or computational approaches to the interpretation of experimentally determined properties at all length scales. Historically, new materials are the cornerstones of technological advances. Today, advanced materials, i.e., high-value-added materials engineered for specialized applications, constitute one of the technology areas of national and international prominence. Intensive efforts are under way worldwide to develop improved and new materials for a diversity of technologies. To tackle problems of this dimension, materials science has evolved into an interdisciplinary research enterprise cutting across traditional boundaries among chemical, electrical, and mechanical engineering, chemistry, optics, and physics. The University of Rochester’s tradition and infrastructure are uniquely suited for nurturing cutting-edge materials research targeting imaging, information, biomedical, and energy technologies.

The Materials Science Program offers MS and PhD degrees. The program draws students from a wide range of educational background: biological, chemical, electrical, and mechanical engineering, materials science, ceramics, chemistry, physics, and optics. It is strongly recommended that applicants take the GRE. The TOEFL or IELTS is generally required of foreign students. Students interested in obtaining materials science degrees are required to design a program of studies consisting of a balance between coursework and research in consultation with thesis advisors associated with one of the participating academic departments.

In the Departments of Biomedical Engineering and Chemical Engineering, a materials science student works on the synthesis, processing, and molecular simulation of advanced materials for aerospace, biomedical, information, energy, and environmental applications. Biomaterials are designed with distinct capabilities, such as controlling cell behavior or overcoming drug delivery barriers. Modern facilities are available for cell and tissue engineering; recombinant DNA and molecular biology; inorganic materials for membrane separation, fuel storage, and gas sensor technology; synthesis, processing, and simulation of functional polymers and molecular materials new fuel cell materials and optimization; device science and engineering for electronics, optics, photonics, and optoelectronics; electrical
engineering applied to microelectronics, energy conversion, and storage; reaction, transport, and phase transition in porous media; organic light-emitting diodes and interfacial phenomena in multiphase systems.

In the Department of Mechanical Engineering, a student working in materials science concentrates on the relation between microstructure and mechanical properties of metals, ceramics, glasses, and polymers. Current projects include nanostuctures catalysis for fuel cell applications, scratching of polymer films, design of ecologically friendly nanostructured solders, impression creep and recovery, microgrinding and polishing of glass and crystalline materials, powder processing, deformation of ionic materials, residual stress measurements, failure and adhesion analysis, piezoelectric materials, corrosion, and the design of fracture-tough materials. The College maintains specialized equipment including electron microscopes, an energy-dispersive X-ray microprobe, several Instron tensile testers, MTS and Instron servo-controlled fatigue machines, nanoindenters, a differential scanning calorimeter, a hot isostatic press, melt-spin apparatus, and state-of-the-art X-ray diffraction equipment.

In the Department of Electrical and Computer Engineering, a materials science student may enter such research areas as the electronic effects of surface preparation in semiconductors and insulators, silicon nanostructures, porous silicon and optoelectronic applications, bulk diffusion effects in semiconductors, ultrafast electronics, and high-temperature superconductors in thin films. Current projects include superconducting and magnetic thin films, microwaves, MEMS, picosecond phenomena, and fluctuations in superconductors.

In The Institute of Optics, a materials science student concentrates on the properties of materials important to optical applications, including nanophotonics. Many topics in the broad areas of optical materials and photonics are appropriate, such as the following: the interaction of light and materials to create new optical effects, interaction of intense laser radiation and matter, new crystals and glasses for manipulating light from the deep UV to the IR, and new technologies for precision manufacture and testing of novel optics. Some examples of current or previously explored subjects include the tribomechanical basis for polishing of optical glasses, improved photonic crystals for fiber laser amplifiers, and characterization of solid-state diffusion in optical index gradient materials.

In the Department of Chemistry, a materials science student can participate in research on making and understanding novel devices based on organic and biological materials. Applications include electroluminescent displays, photovoltaic cells, and biomolecular sensors. Studies vary from the physics of charge transport in organic semiconductors, to the mechanism for current photogeneration, to devising new fabrication and patterning methods that take advantage of the processability of organic materials.

In the Department of Physics, a materials science student can work on the theoretical and/or experimental aspects of condensed-matter physics. Current projects include universality of interfacial fluctuations and cyclic growth; large-scale Monte Carlo simulations of vertex line dynamics in high-Tc superconductors; transport and tunneling phenomena in ultrathin metal films; and interfaces in organic semiconductors and ultrafast dynamics in solids.

A materials science student in the Department of Earth and Environmental Sciences has access to state-of-the-art thermal ionization and inductively coupled plasma source mass spectrometers that are used to determine the trace metal content and isotopic composition of geological, environmental, and biological materials. Research topics include the fate and behavior of carbon nanotubes and fullerenes in nature, mineralogy, crystallography and the study of optical properties of silicates, carbonates, phosphates, and oxides in polarizing light microscopy.

Materials science students may also choose to do research in the School of Medicine and Dentistry in the Departments of Dermatology, Microbiology and Immunology, or Biochemistry and Biophysics. Research topics range from optical biosensing and nanoparticle skin toxicity imaging to computational studies on the molecular-level properties of lipid membranes and the proteins and other molecules that bind to them. The study of nanoparticle-based vaccines delivered under the tongue, or “sublingually,” can be an effective new materials approach to preventing HIV transmission.

**PhD Program**

A typical program for a materials science (MSC) PhD student entering with a BS degree consists of a minimum of 24 credit hours of MSC graduate courses, exclusive of reading courses, 8 credit hours of other related courses, and 58 credit hours of research. A typical program for an MSC PhD student entering with an MS degree consists of a minimum of 24 credit hours of MSC graduate courses plus 36 credit hours of research. Students must successfully complete an oral defense of their theses.

**MS Program**

The MS degree in materials science requires a minimum of 30 credit hours of graduate courses. There are two paths to obtaining an MS: Plan A, with thesis, and Plan B, without thesis. Plan B is the normal, default option for entering students. If students wish to pursue a Plan A path instead, it is the students’ responsibility to make arrangements with a faculty thesis advisor to supervise their work and to inform the MSC program office of this.

For students electing to obtain the MS degree with thesis (Plan A), the following requirements apply: The 30 credit hours must include a minimum of 20 credit hours of MSC graduate courses plus 10 credit hours for research, and students must successfully complete an oral defense of their theses, after all other degree requirements have been completed.

For students electing to obtain the MS degree without a thesis (Plan B), the following requirements apply: The 30 credit hours must include a minimum of 24 credit hours of MSC graduate courses plus 6 credit hours of other related courses. A student in Plan B must pass a comprehensive oral examination. Two formats are offered for the exam: (1) a course-based exam or (2) a literature-based exam.

It is assumed that all incoming students have completed a basic undergraduate course in materials. If not, students must complete MSC 202, Introduction to Materials Science, which is a three-credit-hour course for graduate students. All first-year
graduate students are required to register for the Materials Science Graduate Seminar Series (MSC 496).

Students interested in working towards materials science degrees have a wide range of courses from which to draw in constructing their programs of study. Students are expected to develop their particular program in consultation with their thesis advisor. The current list of MSC courses is provided below. Note that the 200-level courses carry three credits, and that the 400- and 500-level courses carry four credits unless noted otherwise.

202. Introduction to Materials Science
(Same as ME 280)
Prerequisites: ME 226, PHY 122, MTH 163, 164.
Properties of engineering materials including metals, alloys, ceramics, polymers and composites. Relationship of properties to the materials microstructure including atomic bonding, atomic arrangement, crystal structure, co-existing phases, interfaces, defects and impurities. Processing techniques for altering the microstructure and properties.

230. Thermodynamics and Statistical Mechanics
(Same as PHY 227)
Prerequisites: PHY 23, MTH 281 or ME 201 (MTH may be taken concurrently).
Multiplicity of physical states, equilibrium entropy and temperature, Boltzmann factor and partition function, statistical approach to free energy, chemical potential, distribution functions for ideal classical and quantum gases. Applications to chemical reactions, thermal engines, equations of state and phase transitions, applications.

401. Phase Transformation
(Same as ME 408)
Prerequisite: ME 460 or permission of instructor.
How and why atomic rearrangements leading to phase transformations occur and how they are associated with kinetic and crystallographic features; liquid-solid and solid-solid transformations, nucleation theory, growth, massive and martensitic transformations.

402. Bio-Physical Chemistry I
(Same as CHM 402)
Prerequisite: CHM 252 or equivalent.
An introduction to the theory and practical application of several major techniques used in the structural characterization of biological macromolecules. These methods include X-ray crystallography, small angle X-ray scattering, spectroscopic and calorimetric techniques, NMR and comparative modeling. The goal is to enable nonspecialists to become conversant in the language and principles of the field, as well as to understand the strengths and limitations of various techniques.

403. Characterization Methods in Materials Science—Diffraction
(Same as ME 451)
Prerequisite: ME 280 or equivalent.
Crystallography, symmetry elements, space groups, X-ray diffraction from single crystals and powder patterns. Fourier transforms, grain size effects, residual stresses and textures, diffuse and small angle scattering, Bragg and Laue X-ray diffraction topology, thin films and epitaxial layers. Modern X-ray software for diffraction analysis including textures, residual stresses, pattern identification, and Rietveld applications.

404. Bio-Physical Chemistry II
(Same as CHM 404)
Prerequisite: CHM 252 or equivalent.
Credit—two hours
This course explores how fundamental interactions determine the structure, dynamics, and reactivity of proteins and nucleic acids. Examples are taken from the current literature with emphasis on thermodynamic, kinetic, theoretical, and site-directed mutagenesis studies.

405. Thermodynamics of Nano and Microsolids
(Same as ME 460)
Review of basic thermodynamic quantities and laws, equations of state, statistical mechanics, heat capacity, relations between physical properties, Jacobian algebra, phase transformations, phase diagrams and chemical reactions, partial molal and excess quantities, phases of variable composition, free energy of binary and multicomponent systems, surfaces and interfaces. The emphasis is on the physical and chemical properties of solids including stress and strain variables.

407. Solids and Materials Lab
(Same as ME 462)
Prerequisites: ME 280, 226.
Lecture and laboratory. Lecture: engineering problem-solving methodologies and review of basic statistics. Laboratory: dealing with solids/materials instrumentation. Students work in groups of three. Graduate students work alone on independent projects.

408. Microstructure
(Same as ME 463, CHM 423)
Prerequisite: ME 280.
409. Mechanical Properties
(Same as ME 481)
Prerequisites: ME 280, MTH 163 or equivalent.

The mechanical response of crystalline (metals, ceramics, semiconductors) and amorphous solids (glasses, polymers) and their composites in terms of the relationships between stress, strain, damage, fracture, strain-rate, temperature, and microstructure.

413. Engineering of Soft Matter
(Same as CHE 413)
Prerequisites: CHM 203 (or equivalent) and CHE 225 or CHM 251 (or equivalent).

This course provides an overview of several contemporary research topics pertaining to structured organic materials. Lectures focus on intermolecular interactions and the thermodynamics of self-assembly. Additional lectures introduce molecular crystals, polymer crystallinity, liquid crystals, self-assembled monolayers, surfactants, block copolymers, and biomimetic materials.

416. X-Ray Crystallography
(Same as CHM 416)
Prerequisites: CHM 211, 411, or 415; understanding of symmetry operations.
Credit—two hours

In this course students learn the basic principles of X-ray diffraction, symmetry, and space groups. Students also experience the single crystal diffraction experiment, which includes crystal mounting, data collection, structure solution and refinement, and the reporting of crystallographic data.

418. Statistical Mechanics
(Same as PHY 418)
Prerequisites: PHY 227 or equivalent; PHY 407, 408 concurrently.

Review of thermodynamics; general principles of statistical mechanics; micro-canonical, canonical, and grand canonical ensembles; ideal quantum gases; applications to magnetic phenomena, heat capacities, black-body radiation; introduction to phase transitions.

420. Intro to Condensed Matter Physics
(Same as PHY 420)

An emphasis on the wide variety of phenomena that form the basis for modern solid-state devices. Topics include crystals, lattice vibrations, quantum mechanics of electrons in solids, energy band structure, semiconductors, superconductors, dielectrics, and magnets.

426. Semiconductor Devices
(Same as ECE 423)
Prerequisites: ECE 221, PHY 123 or permission of instructor.


432. Optomechanics
(Same as ME 432)

The mechanical design and analysis of optical components and systems are studied. Topics include kinematic mounting of optical elements, the analysis of adhesive bonds, and the influence of environmental effects such as gravity, temperature, and vibration on the performance of optical systems. Additional topics include analysis of adaptive optics, the design of lightweight mirrors, thermo-optic and stress-optic (stress birefringence) effects. Emphasis is placed on integrated analysis, which includes the data transfer between optical design codes and mechanical FEA codes.

433. Polymer Science and Engineering
(Same as CHE 486)
Prerequisites: organic chemistry, physical chemistry, fluid dynamics.

Mechanisms and kinetics of polymerization reactions; solution, suspension, and emulsion polymerization processes; thermodynamics of polymer solutions; the Flory-Huggins theory; principles and practice of membrane osmometry, light scattering, viscometry, and size exclusion chromatography; polymer rheology and mechanical properties; polymer morphology and phase transitions.

436. Molecular Spectroscopy and Structures
(Same as CHM 458)
Prerequisite: CHM 451 or equivalent.
Credit—two hours

This course covers the basic theory and experimental practice of spectroscopy in molecules and condensed matter. A general review of electromagnetic waves is followed by time-dependent perturbation theory and a density matrix treatment of two-level systems. The basic principles are applied electronic, vibrational and rotational spectroscopy. The course draws heavily on literature studies that exemplify the material.

442. Microbiomechanics
(Same as BME 442)
Prerequisite: permission of instructor.

This course covers the application of mechanical principles to biotechnology and to understanding life at its smallest scales. Topics vary with each course offering. Sample topics include force generation by protein polymerization, the mechanisms of bacterial motion, and the separation of biological molecules in porous media.

445. Biomaterials
(Same as BME 445)
Prerequisites: CHM 131, 132, PHY 121, 122, MTH 161, 162, Biomechanics and BIO 110, or permission of instructor.

This course provides a background in biomaterials: basic material properties, specifics on ceramics, polymers and metals used in the body, and special topics related to biomaterials including tissue engineering, biological responses to implanted materials, and drug delivery.
449. Elasticity  
(Same as ME 449)  
Prerequisites: ME 226, 163 or MTH 163.

Analysis of stress and strain, equilibrium, compatibility, elastic stress-strain relations, material symmetries. Torsion and bending of bars. Plane stress and plane strain; stress functions. Applications to half-plane and half-space problems; wedges; notches. 3D problems via potentials.

452. Controlled Release Systems  
(Same as BME 432)  
This course is designed to provide students with an understanding of the principles, strategies, and materials used in controlled drug delivery systems. The course first covers the fundamentals of drug delivery, including physiology, pharmacokinetics/pharmacodynamics, drug diffusion and permeation, and biomaterials used in drug delivery. Controlled release strategies for various administration routes are then discussed.

453. Biomedical Ultrasound  
(Same as BME 451)  
The course presents the physical basis for the use of high-frequency sound in medicine. Topics include acoustic properties of tissue, sound propagation (both linear and nonlinear) in tissues, interaction of ultrasound with gas bodies (acoustic cavitation and contrast agents), thermal and nonthermal biological effects of ultrasound, ultrasonography, dosimetry, hyperthermia, and lithotripsy.

454. Interfacial Engineering  
(Same as CHE 454)  
Prerequisite: CHE 225.

Lectures on the fundamentals of colloids and interfaces, systems with high interfacial area, and their role in modern processes and products. Topics include interfacial tension, contact angle, adsorption, surfactants, micelles, microemulsions, and colloidal dispersions.

455. Thermodynamics and Statistical Mechanics  
(Same as CHM 455)  
Prerequisite: CHM 251 or equivalent.

The course draws connections between the orderly and chaotic behavior of simple and complex systems, laying the foundations of statistical equilibrium and equilibrium thermodynamics. The different phases of matter (gases, liquids, solid) assumed by bulk classical interacting particles and their transitions are discussed in this approximation. Properties of noninteracting quantal systems are expressed in terms of partition functions, for gases of simple and complex particles. Nonequilibrium statistical behavior of multi-particle systems leads to diffusion and other transport phenomena.

456. Chemical Bonds—from Molecules to Materials  
(Same as CHM 456)  
Prerequisite: CHM 251 or equivalent course on quantum mechanics.

An introduction to the electronic structure of extended materials systems from both a chemical bonding and a condensed matter physics perspective. The course discusses materials of all length scales from individual molecules to macroscopic three-dimensional crystals, but focuses on zero-, one-, and two-dimensional inorganic materials at the nanometer scale. Specific topics include semiconductor nanocrystals, quantum wires, carbon nanotubes, and conjugated polymers.

458. Electrochemical Engineering and Fuel Cells  
(Same as CHE 458)  
Credit—two hours

This course concentrates on presenting the principles of electrochemistry and electrochemical engineering, and the design considerations for the development of fuel cells capable of satisfying the projected performance of an electric car. The course is expected to prepare students for the challenges of energy conversion and storage and the environment in the twenty-first century.

460. Solar Cells  
(Same as CHE 460)  
This course introduces students to the basics of photovoltaic devices: physics of semiconductors; pn junctions; Schottky barriers; processes governing carrier generation, transport, and recombination; analysis of solar cell efficiency; crystalline and thin-film solar cells, tandem structures, dye-sensitized, and organic solar cells. Students learn about current photovoltaic technologies including manufacturing processes and also the economics of solar cells as an alternative energy source. Critical analysis of recent advances and key publications are a part of the coursework.

461. Fracture and Fatigue  
(Same as ME 461)  
Prerequisites: ME 280, 226.


462. Cell and Tissue Engineering  
(Same as BME 462)  
Prerequisites: knowledge of chemistry, mass transfer, fluid mechanics, thermodynamics, and physiology.

This course teaches the principles of modern cell and tissue engineering with a focus on understanding and manipulating the interactions between cells and their environment. After a brief
overview of Cell and Tissue Engineering, the course covers five areas of the field. These are (1) Physiology for Tissue Engineering; (2) Bioreactors and Biomolecule Production; (3) Materials for Tissue Engineering; (4) Cell Cultures and Bioreactors; and (5) Drug Delivery and Drug Discovery.

463. NMR Spectroscopy
(Same as CHM 423)
Prerequisites: one year of organic chemistry and one semester of physical chemistry (CHM 251) or equivalents.
Credit—two hours
In this course, students are introduced to NMR spectroscopy. Collection, processing, and interpretation of homonuclear and heteronuclear 1D and multidimensional spectra are covered. Topics discussed include chemical shifts, relaxation, and exchange phenomena. Examples from organic, inorganic, and biological chemistry are used.

464. Fundamentals of Lasers
(Same as OPT 424)
Fundamentals and applications of laser systems, including optical amplification, cavity design, beam propagation and modulation. (For non-optics/physics graduate students.)

468. Chemical Kinetics
(Same as CHM 460)
Prerequisite: CHM 451 or equivalent.
Credit—two hours
Within the broad area of chemical kinetics, this course focuses on basic concepts of kinetics, photochemistry, and electron-transfer (eT). In addition to studying bulk reaction rates, the course also covers Marcus's theory of eT, intramolecular vibrational energy redistribution (IVR) and vibrational cooling, and the fates of photoexcited species (radiative and nonradiative decay channels). Also addressed are the experimental quantification of these kinetics using time-resolved spectroscopy and analysis of kinetic data. The course material is somewhat continuous with that of CHM 458, Molecular Spectroscopy.

469. Biotechnology and Bioengineering
(Same as CHE 469)
The life science and engineering principles underlying biotechnology processes; established biotechnology processes including microbial and enzyme conversions, metabolic pathways, and fermentation kinetics; tools for biotechnology development including the recombinant DNA and monoclonal antibody techniques; emerging areas at the forefront of biotechnology, including immune technology and tissue and organ cultures.

471. Optical Fabrication and Testing
(Same as OPT 443)
Characteristics and properties of optical glass and the methods for fabricating high-quality surfaces and components. Lectures describe applications of such glass in laser systems and nonlinear optics.

472. Biointerfaces
(Same as CHE 492)
The course focuses on interfacial phenomena in hybrid bioorganic systems. The goal of the course is to increase the understanding of interactions between biomolecules and surfaces. The course aims at investigating the behavior of complex macromolecular systems at material interfaces and the importance of such systems in the fields of biology, biotechnology, diagnostics, and medicine. The first part of the course focuses on mechanisms of interactions between biomolecules and surfaces. The second part focuses on the characterization of physical, chemical, and morphological properties of biointerfaces.

473. Introduction to Optoelectronics
(Same as OPT 226)
Prerequisites: OPT 261, 262.
Light propagation in restricted geometries including waveguides and optical fibers. Dispersion and loss in linear and nonlinear pulse propagation. Coupling between passive and between active and passive elements.

474. Nano-Optics
(Same as OPT 463)
Prerequisites: OPT 461, 412.
Examination of theory of strongly focused light, confocal and near-field optical microscopy, atomic decay rates in inhomogeneous environments, single molecule spectroscopy, and optical forces.

480. Chemistry of Advanced Materials
(Same as CHE 431)
Preparation, structure, composition, and properties of advanced materials with emphasis on the underlying chemistry. Atomic structure and bonding of crystalline and amorphous solids and crystalline defect. Materials synthesis and processing by chemical and physical deposition methods. Focus on the relation of structure to properties of materials. Selected topics to illustrate the basic concepts and principles including thin film materials, nanostructure/nanoscale/nanocomposite materials, and bulk materials.

482. Processing Microelectronic Devices
(Same as CHE 482)
Credit—two hours
This course features an overview of processes used in the fabrication of microelectronic devices, with emphasis on chemical engineering principles and methods of analysis. Modeling and processing of microelectronic devices. Includes introduction to
physics and technology of solid state devices grade silicon, microolithography, thermal processing, chemical vapor deposition, etching and ion implantation, and damascene processing.

484. Microelectromechanical Systems  
(Same as ECE 434)  
Prerequisites: MTH 163, 164, PHY 122 (or equivalents).

Static and quasistatic fields for microelectromechanical transducers and certain microfluidic schemes. Capacitance models, lumped parameter electromechanics, and two-port device descriptions. Reciprocity and sensitivity issues.

485. Thermodynamics and Statistical Mechanics  
(Same as CHE 485)

In the beginning, macroscopic thermodynamics including phase equilibria and stability concepts are covered, followed by material related to the principles of statistical mechanics. Applications to various modern areas of the topic are examined including the Monte Carlo simulation method, critical phenomena, and diffusion in disordered media.

491. Master’s Reading Course in Materials Science

Supervised reading and study on topics generally not covered in existing formal courses.

492. Special Topics in Materials Science

A lecture or seminar course at the master’s level on topics of current interest.

ECE 492. Special Topics in Physics and Application of Nanophotic and Nanomechanical Devices

Prerequisites: basic knowledge about electromagnetic waves, waveguides, optoelectronics, and quantum mechanics.

This course aims to provide students with the understanding of fundamental principles governing optical and mechanical phenomena at micro/nanoscale level, with focus on current research advances on device level. The following topics are covered: fundamental concepts of micro-/nanoscale optical cavities and mechanical resonators; various types of typical nanophotonic and nanomechanical structures; fabrication techniques; theoretical modeling methods and tools; physics and application of optical and mechanical phenomena at mesoscopic scale; state-of-the-art devices and current research advances.

493. Master’s Essay in Materials Science

Supervised preparation of the master’s essay for Plan B candidates.

495. Master’s Research in Materials Science

496. Materials Science Graduate Seminar

507. MSC Seminar Practicum  
(Same as OPT 507)

Overview of techniques for using the SEM (Scanning Electron Microscope) and Scanning Probe (AFM, STM) and analyzing data. Students perform independent lab projects by semester’s end.

520. Spin-Based Electronics  
(Same as ECE 520)

Prerequisites: permission of instructor and familiarity with elementary quantum mechanics.

Basic physics of magnetism and of quantum mechanical spin. Aspects of spin transport with emphasis on spin-diffusion in semiconductor.

541. Nanoscale Crystalline Defects  
(Same as ME 541)

This course is a thorough study of the means by which defects in crystalline lattices control the observable macroscopic properties of single phase materials. The properties under consideration are mechanical properties, electrical properties, optical properties, and chemical properties. The defects of interest include point, line, and planar defects, including charged defects that determine internal friction, yield strength, transparency and translucency, chemical potential, stored energy, electrical resistivity, dielectric response. Knowledge of how such defects determine important engineering properties of solids is a fundamental requisite for all areas of materials research.

(Same as ECE 580)

Prerequisite: permission of instructor.

Introduction to the scientific foundations of nanoscience and the materials science that makes it possible to focus on developments in three major domains of applications, electronics, photonics, and biosensing.

552. Special Topics in Materials Science

Subject matter to be selected by the instructor from among topics of current interest in materials science.

591. PhD Reading Course in Materials Science

Supervised reading on topics beyond those available in existing courses, or on specialized topics.

592. Special Projects in Materials Science

595. PhD Research in Materials Science
Mechanical Engineering

Professors Betti, Burns, R. Clark, Funkenbusch, Gans, *Genberg, Gracewski, Lambropoulos (Chair), Li, McCrory, Meyerhofer, Perucchio, Quesnel, Thomas
Associate Professor Ren
Assistant Professors Ellis, Nam
Assistant Professor (Research) Guazzotto
Adjunct Professor Wu
Adjunct Assistant Professors *Goncharov, *Maximov
Joint Appointments: Professor Waugh; Associate Professor Lerner
Lecturers Agbezuge, Davies, *Gao, Muir, Rice, *Ronald
Professors Emeriti A. Clark Jr., Goldman, Simon

The Department of Mechanical Engineering offers graduate work leading to both the MS and PhD degrees in mechanical engineering and in materials science. Applicants for admission are expected to have a general background in one of the following areas, depending on degree program and interest: engineering, physics, applied physics, applied mathematics, materials science, mechanics, metallurgy, or chemistry. It is strongly recommended that applicants take the Graduate Record Examination (GRE). Scores from the Test of English as a Foreign Language or International English Language Testing System (TOEFL/IELTS) are required of foreign applicants.

Faculty research in the department falls into two broad categories: solid mechanics-materials science and fluid mechanics-plasma physics. Much of this work is interdisciplinary and takes advantage of links between the Department and the Laboratory for Laser Energetics (LLE), the Rochester Center for Biomedical Ultrasound (RCBU), and the School of Medicine and Dentistry (SMD), as well as the Departments of Physics and Astronomy (DPA), Biomedical Engineering (BME), and the Institute of Optics in the College.


Applications and research projects in fluid mechanics-plasma physics include fusion research (LLE, DPA): inertial confinement fusion and magnetic confinement fusion; hydrodynamic theory and simulations of inertial fusion implosions; experimental studies of laser-driven implosions; particle-in-cell simulations of laser-plasma nonlinear interactions; hydrodynamic stability and nonlinear waves (Rayleigh-Taylor instability and parametric instabilities); experimental studies of the scattering of radiation from laser-produced plasma; plasma diagnostics; the investigation of X-ray sources; experimental studies of the interaction of very short pulse; high-intensity lasers with matter; particle acceleration in plasmas; magnetohydrodynamic equilibrium and stability of tokamak plasmas; plasma dynamics, kinetic theory and wave-particle interaction. Astrophysical magnetohydrodynamics (DPA): astrophysical fluid dynamics and magnetohydrodynamics including the physics of sunspots, dynamos in the Sun and other stars, and the formation of planetary nebulae. Low Reynolds number studies (COM): characterization of non-Newtonian fluids as applied to optics manufacturing, analytic and numerical studies of nonlinear lubrication dynamics as in web transport and related problems, surface roughness.

PhD Program

The PhD degree requires 90 semester hours of graduate credit. A typical program includes about 40 to 60 hours of coursework, with the remaining hours in PhD research. Candidates are required to take at least 24 hours of coursework at the 400 level or higher, of which at least 14 should be in mechanical engineering courses. Each student is assigned a faculty advisor, who should be consulted in choosing the remaining courses.

Opportunities for research are provided during the academic year and the summer following the first year in residence. Students are expected to take advantage of these opportunities to help them choose a dissertation advisor and to begin what may become their eventual dissertation work.

All students must take a preliminary examination near the end of their second semester in residence. Each student’s performance on this exam, along with course grades and research aptitude, are considered in a faculty evaluation of his or her progress. Passing the exam with a positive faculty evaluation is a requirement for continuation in the PhD program.

Students who pass the preliminary exam and faculty evaluation are expected to take an oral PhD qualifying exam early in their third year of graduate study. Research from the first and second years may form the basis for this exam, which emphasizes material from the student’s field of study.
Because of the increasingly interdisciplinary nature of engineering, opportunities also exist for the pursuit of joint PhD programs between mechanical engineering and materials science, or mechanical engineering and biomedical engineering. Students in the joint programs must satisfy the degree requirements of both programs. Admissions and examinations are administered by faculty from both programs involved.

**MS Program**

The MS degree requires 30 semester hours of graduate credit. For candidates in Plan A, 6 to 12 hours of the 30 required will be for MS research leading to a master's thesis. Of the remaining 18 to 24 hours, at least 16 must be in courses at the 400 level or higher and at least 12 of these 16 must be in ME courses.

Candidates in Plan B must take at least 18 of the required 30 hours in the Department of Mechanical Engineering, and at least 16 of these 18 must be in courses at the 400 level or higher, excluding reading and research courses. They must also pass a comprehensive examination taken during their final year of MS studies. Those candidates for the MS degree under Plan B who do not intend to continue on for a PhD have the option of substituting an oral examination for the comprehensive examination noted above. This examination may not be taken until after the completion of the MS course program. The oral examination must then be held within one year of such completion. Students failing either examination may be permitted, at the discretion of the department, to retake the examination at a later time.

Students seeking the MS degree in mechanical engineering will normally take a program which emphasizes courses in the various energy and mechanics areas. Those seeking an MS degree in materials science will normally take a program which emphasizes courses in the materials area. Materials science degree requirements and a list of graduate courses which are particularly appropriate may be found in the section on the Materials Science Program (page 133).

All courses in the Department of Mechanical Engineering are taught by full-time faculty members with professorial rank or by part-time faculty members with the rank of lecturer (part time) or professor (part time). Graduate students may assist as graders and conduct some of the recitation classes.

The following 200-level courses carry three credit hours; the 400- and 500-level courses carry four credit hours unless otherwise noted.

**213. Mechanical Systems**  
Prerequisites: ME/MATH 163 and 164; ME 121 and 226.

**222. Introduction to Robust Design and Quality Engineering**  
Prerequisite: ME/MTH 164 or permission of instructor.

**223. Heat Transfer**  
Prerequisites: ME 123, 225.

**225. Introduction to Fluid Dynamics**  
Prerequisites: ME/MTH 163 and 164; ME 120, 123.

**226. Introduction to Solid Mechanics**  
Prerequisites: ME 120 and ME/MTH 164.

**232. Optomechanics**  
Prerequisites: ME 226, 204.

**241. Fluid Dynamics and Thermal Sciences Laboratory**  
Prerequisite: ME 225.

**242. Solids and Materials Laboratory**  
Prerequisites: ME 121, 226, 241, 280.

**250. Optimum Design**  
Prerequisites: ME 226, 204 (or equivalent), and some programming experience.

**251. Heat Power Applications**  
Prerequisites: ME 123 and 225 (may be taken concurrently).

**253. Intro to Nuclear Engineering**  
Prerequisites: PHY 123, ME 123.

**280. Introduction to Materials Science**  
Prerequisites: ME/MTH 163 and 164; PHY 123.

**281. Mechanical Properties of Solids**

**400. Applied Boundary-Value Problems**  
(Same as ME 201)

Formulation of partial differential equations for physical problems; Fourier series; separation of variables leading to Fourier series; Sturm-Liouville theory; eigenfunction expansions and separation of variables; Fourier transform; similarity methods; Fourier-Bessel expansions and separation of variables in cylindrical coordinates; Legendre polynomials and separation of variables in spherical coordinates. Equations dealt with in the course are the Laplace equation, the heat equation, the wave equation, and related equations. Applications are to such areas as heat conduction, fluid flow, diffusive mass transport, electrostatics, and acoustics. Requires significant extra work at the 400 level.
401. Methods of Applied Mathematics  
**Prerequisite:** ME 201 or MTH 281; MTH 282.

Advanced ordinary differential equations (ODEs), boundary layer theory, WKB method, multiple-scale analysis, asymptotic expansion of integrals, renormalization group.

402. Partial Differential Equations  
**Prerequisite:** ME 201 or MTH 281 and ME 202/MTH 282.

Green's functions and eigenfunction expansions; application to the Laplace, diffusion, and wave equations. First-order equations and the theory of characteristics; Green's functions for wave propagation; dispersive waves. Boundary layers and matched asymptotic expansions.

403. Computational Methods for Engineering and Science  
**Prerequisite:** ME 402 or PHY 401 or OPT 411, or consent of the instructor. Some FORTRAN experience desirable.


404. Computational Methods Applied to Biological Systems  
Computational methods to solve analytically intractable mathematical problems in biological research. Using MATLAB as a programming language; numerical methods for linear algebra, ODE, and PDE; case studies such as biodynamics of human locomotion, ion channel kinetics, ionic diffusion in cells, and finite element analysis of cells/tissues.

406. Dynamical Systems  
**Prerequisite:** MTH 165.

Plane autonomous systems: phase plane, stability of equilibrium by linearization; stability by Liapunov methods; periodic solutions and their stability; global phase portraits; bifurcations. Higher order autonomous systems: matrix methods for linear systems; local behavior near equilibrium points; Lorenz equations and chaotic solutions; tent map and Lorenz equations; Liapunov exponents. Driven systems: Duffing's equation; the driven pendulum.

407. Advanced Dynamics  
**Prerequisites:** ME 121, 213, and ME/MTH 163.

Review of principles of mechanics; generalized coordinates and constraints; calculus of variations; Lagrange's equations; Hamilton's equations; rigid body dynamics; applications.

408. Phase Transformation in Metals and Alloys  
**Prerequisite:** ME 460.

The physical, chemical, and mechanical properties of metals and alloys can be varied drastically by thermal and mechanical treatments. This phase transformation course is concerned with a description of how atomic rearrangements occur and how they are associated with kinetic and crystallographic features.

411. Mechanical Properties of Polymers  
**Prerequisite:** permission of the instructor.

Structure of polymers, elastic behavior, finite strain elasticity, viscoelastic behavior of polymers, time-temperature superposition, free volume theory, relaxation processes, nonlinear and anisotropic behavior, yielding and fracture.

424. Introduction to Robust Design and Quality Engineering  
(Same as ME 222, MSC 424)  
**Prerequisite:** MTH 164 or equivalent.

Definition and pursuit of “quality” as a design criterion. The concept of robust design. Selection of the quality characteristic and experimental design to improve quality. Cross-listed as ME 222, but requires significant extra work.

432. Optomechanics  
**Prerequisites:** ME 226 and 204.

Design of structures to support optical components such as lenses, mirrors and telescopes for UV, visible and IR optical applications. Extensive use of finite element methods in optomechanical design and optimization.

434. Introduction to Plasma Physics I  
**Prerequisite:** EE 231 or PHY 217.

Orbit theory, adiabatic invariants, collective effects, two-fluid and MHD equations, waves in plasma, transport across magnetic fields and in velocity space.

435. Introduction to Plasma Physics II  
**Prerequisite:** ME 434.

Vlasov equation, Landau damping, Van-Kampen modes, shield clouds, two-stream instability, microinstabilities, drift instability, nonlinear instability theory, radiation from plasma.

436. Compressible Flow  
**Prerequisites:** ME 225 and ME 201 or MTH 281.

Equations of motion, acoustics; linearized equations for homogeneous media; mathematical theory of linear waves; geometrical acoustics. Nonlinear simple waves, Riemann invariants. Finite amplitude compressible flow; one-dimensional waves and the theory of characteristics; shock waves; steady two-dimensional flow. Dimensional analysis, self-similar flows. Combustion and detonation.

437. Incompressible Flow  
**Prerequisites:** ME 225 and ME 201 or MTH 281.

Conservation equations. Bernoulli's equation, Navier-Stokes equation. Inviscid flows; vorticity; potential flows; stream function; complex potential. Viscosity and Reynolds number; some exact solutions with viscosity; boundary layers; low Reynolds number flows. Selected applications from aerodynamics. Waves.
440. Mechanics of Structures
Prerequisite: ME 226.
Application of direct and indirect methods of the calculus of variations to the stress, deflection, and dynamic analysis of beam, ring, plate, and shell elements. Strain energy and complementary strain energy; variational principles; Lagrange multipliers. Rayleigh-Ritz method; Galerkin method; Reissner’s variational principle.

441. Finite Elements
(Same as BME 486)
Prerequisites: ME 226 and programming capability in Matlab.
The theory and application of finite element analysis to linear problems in structural mechanics and other disciplines. Topics: matrix analysis concepts; element formulation methods; element behavior; global analysis aspects; isoparametric elements. Term project requires the implementation of a finite element program in MATLAB.

443. Applied Vibrations
Prerequisite: ME 213.
One, two, and many degrees-of-freedom systems. Complex representation; free and forced vibration; transient vibration; damping. Vibration of strings, beams, and membranes.

444. Continuum Mechanics
Prerequisites: ME/MTH 164, ME 201, ME 225, ME 226.

445. Plates and Shells
Prerequisites: ME 226; ME 201 or MTH 281.
Analysis of stress and deformation in rectangular and circular plates bent by transverse loads. Axisymmetric deformation of shells of revolution. Asymptotic expansions; membrane and bending stress. Application to pressure vessels, tanks, and domes with various support and load conditions.

446. Wave Propagation in Elastic Media
Prerequisites: ME 121, 226; ME 201 or MTH 281.
Physical phenomena (reflection, dispersion) and mathematical techniques (Green’s functions, Fourier analysis, stationary phase) are studied for waves on strings. Concepts are then used to study waves in infinite, semi-infinite, and layered structures and waves in layers and cylinders.

448. Structural Stability
Prerequisite: ME 226. Strongly recommended: ME 201 or MTH 281.
Concepts of equilibrium and stability of deformable solid structures. Applications to elastic columns, plates, and shells. Interactions with fluids. Static and dynamic systems.

449. Elasticity
Prerequisites: ME 226; ME/MTH 163.
Analysis of stress and strain; equilibrium; compatibility; stress-strain relations. Torsion and bending of bars. Plane stress and plane strain; Airy stress functions. Half-plane problems. 3-D elasticity; Papkovich-Neuber, Love potentials. Applications to problems for the half-space.

450. Optimum Design
Prerequisites: ME 226, ME 204 (or equivalent), and some programming experience.
Nonlinear programming techniques are applied to optimize the mechanical design problem. Both constrained and unconstrained techniques are discussed. Students use state-of-the-art software to solve a variety of problems. The combination of optimization with finite elements is addressed.

451. Crystallography and X-Ray Diffraction
Prerequisite: permission of instructor.
Crystallography, symmetry elements, point groups, space groups, X-ray diffraction, single crystal diffraction, powder patterns, Fourier transforms, grain size effects, residual stress and cold work, diffuse and small-angle scattering, Bragg and Laue, X-ray topography. Weekly laboratory.

452. Electron Microscopy
(Same as BME 454)
Prerequisites: ME 451 and permission of instructor.
Microstructural features and their effect on mechanical, electrical, and optical properties. Point, line, and planar defects; kinematical theory of diffraction; reciprocal space; single crystal diffraction patterns; dynamical theory of diffraction; direct observations of dislocations and stacking faults. Weekly laboratory involving use of electron microscope.

453. Intro to Nuclear Engineering
(Same as ME 253)
A first course in nuclear engineering with emphasis on the fundamental physics and technology of modern water-cooled power reactors, the nuclear fuel cycle, and the regulatory environment surrounding nuclear power in the United States.

458. Nonlinear Finite Element Analysis
(Same as BME 487)
Prerequisite: ME 441 or equivalent.
The theory and application of nonlinear finite element analysis in solid and biosolid mechanics. Topics: generalization of FE concepts, review of solid mechanics, nonlinear incremental analysis, displacement-based FE formulation for large displacements and large strains, nonlinear constitutive relations, incompressibility and contact conditions, hyperelastic and viscoelastic materials, biomechanical materials, solution methods.
459. Applied Finite Elements

Prerequisite: ME 441 or permission of instructor. The course addresses practical topics in finite elements, including vibrations, buckling, structural symmetry, superelements, and fracture mechanics. Modeling techniques and applications to problem solving are stressed using commercial FEA codes.

460. Thermodynamics of Solid Materials

Prerequisite: ME 123 or CHE 225.

Review of basic thermodynamic quantities and laws; phase transformations and chemical reactions; partial molar and excess quantities; electrochemical reactions; free energy of binary systems; surfaces and interfaces; nucleation of neophases; stressed solids; irreversible thermodynamics.

461. Fracture and Fatigue

Prerequisites: ME 280, 226, and 442.

Linear elastic fracture mechanics. Griffith theory. K and J approaches to toughness measurements. Low-cycle fatigue. Crack nucleation and fatigue crack growth. Failure analysis. Emphasis on the role of microstructure in determining fracture and fatigue behavior. This is a course taught to bring the student at or near the level of current research.

462. Solids and Materials Laboratory

(Same as ME 242, but requires significant extra work.)

Prerequisite: permission of instructor.

Design, planning, execution, and reporting of laboratory experiments, including both existing experiments and a significant independent research project.

463. Microstructure

Prerequisite: ME 280.


466. Electrochemistry and Corrosion

A scientific approach to understanding and thereby controlling metallic corrosion. Starting from general principals of materials science, this course explores the physics that controls chemical degradation.

483. Biosolid Mechanics

Prerequisite: ME 226.

Application of engineering mechanics to biological tissues including soft tissue and bone. Experimental and computational methods and material models of biological structures.

491. Reading Course on Mechanical Engineering

Credit to be arranged

Supervised reading on topics beyond those available in existing courses, or on specialized topics. The students in general make a thorough search and study of the literature dealing with the current research in a given field.

492. Precision Engineering

Precision engineering is used to design and develop sensors, systems, and instruments, which are generally multidisciplinary and require simultaneous consideration of many facets to achieve a desired specification. Precision engineering pushes the current state of the art into new frontiers. The goal of this course is to develop a fundamental understanding of the tools and techniques used for designing, assessing, and ultimately implementing precision systems.

493. Master’s Essay

Supervised preparation of the master’s essay for Plan B candidates.

495. Research in Mechanical Engineering

Credit to be arranged

532. Magnetohydrodynamics


533. Inertial Confinement Fusion

(Same as PHY 558)


535. Laser-Plasma Interactions

Prerequisite: ME 434 or permission of instructor.


536. Hydrodynamic Stability

Prerequisites: ME 434 and 435 or permission of instructor.


537. Advanced Topics in Fluid Mechanics

Credit—two to four hours

Content of the course varies from year to year, but may include such topics as perturbation methods in fluid mechanics, flow phenomena involving ionizing, dissociating, or reacting gases, higher approximations in boundary layer theory, the study of water waves, rotating flows, and solar magnetohydrodynamics.
540. Advanced Topics in Materials Science  
**Credit—two to four hours**  
Topics vary from year to year. Examples are as follows: deformation of amorphous solids, dislocation dynamics, defect mechanisms in polymers, micromechanics of fracture and fatigue, structure and properties of grain boundaries and interfaces, disclinations, deformations of glasses with applications to optics manufacturing.

544. Advanced Topics in Solid Mechanics  
**Credit—two to four hours**  
Content of the course varies from year to year but may include such topics as advanced experimental design, wave propagation, nonlinear elasticity, biomechanics, composite materials, and finite elements.

545. Advanced Topics in Plasma Physics  
**Credit—two to four hours**  
The course content varies from year to year but includes topics which introduce the student to problems of immediate interest in the field. Examples are controlled fusion reactor concepts, including laser fusion, energy in the future, space plasmas, and astrophysical plasma phenomena.

591. Reading Course in Mechanical Engineering  
**Credit to be arranged**  
Supervised reading on topics beyond those available in existing courses, or on specialized topics.

595. Research in Mechanical Engineering  
**Credit to be arranged**

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**The Institute of Optics**

Professors Agrawal, Boyd, Brown, Fienup, George, Knox, Moore, Novotny, Rolland, Stroud, Teegarden, Wicks, Williams, Zhang (Director)  
Associate Professors Alonso, Bentley, Berger, Guo, Zavislan  
Assistant Professors Ellis, Vamivakas  
Assistant Professors (Research) Bentley, Marcianete  
Adjunct Professor Walmsley  
Adjunct Assistant Professors Berg, Buralli, Kruschwitz, Nelson, Oliver  
Joint Appointments: Professors Bigelow, Eberly, Foster, Jacobs, Krauss, Wolf; Associate Professors Seka, Yoon  
Lecturer McIntyre  
Senior Scientist Lukishova, Vorobyev  
Professors Emeriti Givens, Thompson

The Institute of Optics is devoted to teaching and research in optics and optical engineering. It offers programs leading to BS, MS, and PhD degrees. Instruction and research are offered in virtually every phase of optics, including physical optics, optical instrumentation and design, quantum optics, laser engineering, signal processing, guided wave optics, nonlinear optics, and optical materials. Well-equipped laboratories allow student thesis research in a wide range of areas including gradient index optics, image processing, integrated optics, dielectric thin films, ultrahigh resolution laser spectroscopy, and high-power laser physics.

A great deal of optics-related research is carried out in other parts of the University. These programs are described in other parts of this bulletin under the headings Center for Visual Science, Laboratory for Laser Energetics, Electrical and Computer Engineering, and Physics and Astronomy.

There is no foreign language requirement for graduate students in optics. Entering students ordinarily have a BS in physics, engineering, or mathematics, with a grade-point average of 3.0 or better. Scores from the Test of English as a Foreign Language (TOEFL) are required of foreign applicants, unless they are graduates of a U.S. undergraduate program.

Catalog supplements providing the most recent information on course content and faculty research may be obtained on request from The Institute of Optics.

**PhD Program**

It is expected that students completing this program in optics will be ready to assume a role as independent researchers in a university, industrial, or government laboratory. Most of the time in the program is devoted to learning specialized research skills and carrying out thesis research. However, it is also important that the students master the subject matter and develop a breadth of interest in the whole field of optics. To this end, a set of required core courses, a number of elective courses, and a preliminary examination are included in the program.

First-year financial support is usually in the form of a fellowship allowing the students to devote full time to coursework. Four courses are taken each semester. The purpose of the first
MS Program

The master's degree program is designed to provide students who have a strong undergraduate preparation in physics, electrical engineering, or optics with the knowledge and skills to contribute to state-of-the-art optics research and development. A number of options are available within the general degree requirements to satisfy the needs of students with a variety of goals in mind.

A minimum of 30 credit hours is required for the degree. Normally, no more than 10 hours are accepted as transfer credits, and those must be approved by the Graduate Committee and the associate dean for graduate studies. The MS in optics is available to both full-time and part-time students. As outlined under general University regulations in this bulletin, the optics MS can be pursued under either Plan A or B. There is a required set of core courses common to all options within the MS program: Geometrical and Instrumental Optics, OPT 441; Physical Optics, OPT 461 or 462; a laboratory course, OPT 256; and Radiation and Detectors, OPT 425. The laboratory course is not required for part-time students. The remaining credits are obtained by taking elective courses or through research credits. The grade point average of all courses counted toward the degree must be "B" or greater.

The various options and exceptions to these general rules are described below:

*Plan A:* The requirements are the core requirements listed above, one or two additional 400-level optics courses, thesis research and written MS thesis, and successful final defense of the MS thesis. Credit for the thesis may not be less than 6 nor more than 10 hours.

*Plan B:* The standard requirements are the core requirements listed above, one additional course in physical optics, one additional course in quantum optics, one additional course in geometrical optics, one additional course to reach a total of 30 semester hours, and a research essay. The elective courses are normally 400-level specialized courses in optics. Also available is an alternative set of requirements that enables a more concentrated study in certified specialty areas, such as Optical Communications, Nonlinear Optics, Optical Materials, Laser Engineering, Medical Optics, Image Science, Optical Design and Testing, and Business Administration. For more information, see the Optics Graduate Catalog Supplement available from The Institute of Optics.

BS-MS Program

Undergraduate juniors majoring in optics may apply for admission into a five-year program leading to both a BS and an MS degree in optics. Students apply for admission into this program in the spring of their junior year and can begin graduate level coursework during the senior year. Students must meet all of the requirements for the BS degree as well as those for the MS degree. Students may follow the master’s thesis (Plan A) or the non-thesis (Plan B) route.

The thesis route is particularly recommended as it allows the student to develop a very high level of expertise in a specialized field of optics.

The normal fourth- and fifth-year programs for students in this program:

**FOURTH YEAR**

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<td>OPT 225*</td>
<td>OPT 256*</td>
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<td>OPT 425</td>
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The normal fifth-year program should follow that for the master's student Plan A or Plan B. However, the student in the BS-MS program is expected to elect more advanced courses in the fifth year or to start independent thesis work. A representative fifth-year program:

**FIFTH YEAR**

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BS-MS students following a Plan B program will satisfy the regular requirements for the BS degree as well as those for the MS degree but will normally substitute more advanced electives in place of some of the core courses.

To apply, students must be in good academic standing and have completed all of the required courses through the first semester of the junior year. Students may also compete with other MS candidates for financial aid in the fifth year.

* No more than six credit hours below the 400-level are permitted in the master's program of study.
MS Cooperative Program
The curriculum and requirements for this program are the same as those for our regular program. The program, admission to which is subject to the approval of the Graduate Committee, consists of three blocks: (1) a four-month semester at the University of Rochester; (2) a 12-month period spent working in industry; and (3) a second four months at the University of Rochester to complete the master's program.

In order for students to participate in the work block of the program, they must satisfactorily complete the academic block. Failure to do so will result in termination from the program. Students will, of course, have to fulfill the normal conditions of employment at the various corporations (these conditions may include, for example, passing a health examination, signing nondisclosure agreements, etc.). During the work block, students are paid wages comparable to those of other employees with similar educational backgrounds and experience.

During the time students are employed in industry, they are registered for a special co-op program and will have all of the normal rights and privileges of matriculated students, even though they are not in residence during that period.

Part-Time Master’s Programs
All optics courses taken by part-time students are the regular offerings taken by full-time students. Required and elective courses are scheduled so that several are available each semester in the late afternoon as a convenience to part-time students. Part-time students should consult the general University MS regulations in this bulletin for information concerning maximum time limits, retroactive credit, and transfer credit.

Students in the part-time program usually do not write an MS thesis and are not required to take OPT 256.

The following 200-level course carries three credit hours; the 400- and 500-level courses carry four credit hours or as noted.

256. Optics Laboratory
Prerequisite: OPT 242 and 261 or permission of instructor.

Intensive laboratory course, with experiments on optical imaging systems, diffraction, interference, holography, lasers, detectors, spectroscopic instruments, and optical communications systems.

407. Scanning Electron Microscopy Practicum
Overview of techniques for using the SEM (Scanning Electron Microscope) and Scanning Probe (AFM, STM) and analyzing data. Students perform independent lab projects by semester's end.

411. Mathematical Methods for Optics
Prerequisite: ME 201, 202 or equivalent, and permission of instructor.

Study of mathematical techniques such as vector calculus, series expansions, contour integration, integral transforms (Fourier, Laplace, and Hilbert), asymptotic estimates, and second order differential equations.

412. Quantum Mechanics for Optics
Prerequisite: one course in undergraduate wave mechanics or permission of instructor.

This course covers the topics in modern quantum theory which are relevant to atomic physics, radiation theory, and quantum optics. The theory is developed in terms of Hilbert space operators. The quantum mechanics of simple systems, including the harmonic oscillator, spin, and the one-electron atoms, are reviewed. Also, methods of calculation useful in modern quantum optics are discussed. These include manipulation of coherent states, the Bloch sphere representation, and conventional perturbation theory.

421. Optical Properties of Materials
Prerequisite: undergraduate quantum mechanics.

The course concerns the aspects of the solid-state physics of materials, which influence their optical properties. Semiconductors are emphasized, but metals and insulators are treated also. The physics of optical absorption, emission, reflection, modulation, and scattering of light is covered. Optical properties of electrons, phonons, plasmons, and polaritons are detailed. The optical properties of reduced dimensionality structures such as quantum wells are contrasted with those of bulk semiconductors.

424. Fundamentals of Lasers
Prerequisite: permission of instructor. Not available for optics and physics graduate students.

Fundamentals and applications of lasers and laser systems, including optical amplification, cavity design, beam propagation, and modulation. Emphasis is placed on developing the basic principles needed to design new systems, as well as an understanding of the operation of those currently in use.

425. Radiation and Detectors
The course covers the following topics: emission of thermal radiation, modeling of optical propagation (radiometry), quantifying the human perception of brightness (photometry) and of color (colorimetry), fundamentals of noise in detection systems, parameters for specifying the performance of optical detectors, and a survey of several specific types of detectors.

427. Optical Liquid Crystals
This course introduces the materials, terminology, effects, and devices used in the field of liquid crystal optics. Basic structures in nematic and cholesteric liquid crystals are discussed and related to optical phenomena like transmittance, absorption, scattering birefringence and selective reflection (the effect seen in scarab beetles and utilized to protect the OMEGA laser at LLE from blowing itself up). Two keys for device applications are LC chemical composition and molecular alignment, and these are covered in order to understand the manufacture and operation of passive devices like wave plates and selective reflection polarizers. The basic electro-optics for active devices like EO switches and LC displays are covered. Other applications explored include mood rings, polarizing pigments for document security, smart windows, and car paint.
428. Optical Communications

The course is designed to give the student a basic understanding of modern optical communication systems while making them aware of the recent technological advances. The following topics are covered: analog and digital signals, multiplexing techniques, modulation formats, dispersive and nonlinear effects in optical fibers, light-emitting diodes and semiconductor lasers, receiver design, noise and signal-to-noise ratio, bit error rate, optical amplifiers, dispersion management, multichannel systems, soliton systems, coherent lightwave systems.

432. Opto-Mechanical Design

The mechanical design and analysis of optical components and systems are studied. Topics include kinematic mounting of optical elements, the analysis of adhesive bonds, and the influence of environmental effects such as gravity, temperature, and vibration on the performance of optical systems. Additional topics include analysis of adaptive optics, the design of lightweight mirrors, thermo-optics and stress-optics (stress birefringence) effects. Emphasis is placed on integrated analysis, which includes the data transfer between optical design codes and mechanical FEA codes. A term project is required.

441. Geometrical Optics

This course is designed to give the student a basic working knowledge of image-forming optical systems. The course is oriented toward problem solving. Material covered includes image formation, paraxial and real ray-tracing, and first-order properties of systems; matrix formulation of paraxial optics, magnification, F/number, and numerical aperture; stops and pupils, telecentricity vignetting; telescopes, microscopes, the eye and visual systems, field lenses; optical glasses, the chromatic aberrations, and their correction; derivation of the monochromatic wavefront and transverse ray aberrations and study of their effects upon the image; third-order properties of systems of thin lenses; effects of stop position and lens bending; aplanatic, image-centered, and pupil-centered surfaces; field flatteners, introduction to aberration tolerances, and image quality assessment.

442. Geometrical Instrumental Optics

Prerequisite: OPT 441.

This course provides an in-depth understanding of the principles and practices of optical instrumentation: optical metrology, including wavefront and surface metrology, interferometric instruments and interferogram analysis, coherence and coherence-based instruments, phase measurement and phase-shifting interferometry; spectroscopic instrumentation, including the Fourier Transform Spectrometer, the Fabry-Perot interferometer, and the grating monochromator; image plane characterization (star test, Ronchi test, and modulation transfer function); the influence of illumination and partial coherence on image forming systems, including microscopes, systems for projection lithography, and displays.

443. Optical Fabrication and Testing

This laboratory and lecture course is designed to give a firsthand working knowledge of optical glasses, their properties, and the methods for fabricating and characterizing high-quality glass surfaces and components. Lectures emphasize the physical and optical properties of glass, methods for manufacturing glasses, the component finishing process (grinding and polishing), cleaning, finished element specification, chemical durability, and optical quality evaluation methods. New glasses and their applications in laser systems and nonlinear optics are described. The laboratory is designed to expose the student to several varieties of optical glasses, the methods for cold working glass blanks, and the fabrication and testing of selected optical elements. Hands-on activity with grinding and polishing equipment is required to complete one of a variety of projects.

444. Lens Design

Prerequisite: OPT 441.

The course begins with a review of geometrical optics and first-order aberration theory. Then lens design specification documents and image assessment (ray intercept plots, wavefront analysis, spot diagrams, MTFs, and point spread functions) are discussed. Additional topics in lens design to be covered include optimization theory, damped least squares, global optimization, merit functions, variables, and constraints; glass, plastic, UV, and IR materials; aspheres, GRINs, and diffractive optics; second-spectrum, spherochromatism, higher order aberrations and induced aberrations; splitting and compounding lens elements; aplanats and anastigmats. The following refractive design forms are discussed in detail: landscape lens, achromatic doublet, Cooke triplet, Double Gauss, Petzval lens, wide-angle, telephoto, and eyepieces. The following reflective design forms are also covered: parabola, Cassegrain, Schmidt, Ritchey Cretian, Gregory, three-mirror anastigmat, and reflective triplet. Computer-aided lens design exercises are required using commercially available software including a one-week midterm design project and a four-to-six week individual lens design project at the end of the semester.

445. Precision Engineering

Used to design and develop sensors, systems, and instruments, which are generally multidisciplinary and require simultaneous consideration of many facets to achieve a desired specification. Precision engineering is used to push the current state of the art into new frontiers. The goal of this class is to develop a fundamental understanding of the tools and techniques used for designing, assessing, and ultimately implementing precision systems.

446. Optical Interference Coating Technology

This course addresses the design, manufacture, and quality control of optic interference coatings. Topics covered include reflection and transmission at an interface; the vector diagram; the Smith Chart; properties of periodic media; design of high reflectors, bandpass filters, and edge filter; use of computer programs
for design analysis; production techniques; thickness monitoring; thickness uniformity calculations.

447. Advanced Optical Interference Coatings  
Prerequisite: OPT 246/446 or permission of instructor.

This course covers such topics as the effects of dispersion, scatter, and inhomogeneity in multilayer interference coating designs. Attention is given toward manufacturability of designs and meeting common optical specifications. Design assignments address fields including, but not limited to, ophthalmic, lighting, display, infrared applications, lasers, and telecommunications. Each student is given access to current market design, optical characterization, and post-process analysis software.

448. Vision and the Eye  
The human visual system is the most sophisticated imaging system known. This course reveals the intricate optical and neural machinery inside the eye that allows us to see. It describes the physical and biological processes that set the limits on our perception of patterns of light that vary in luminance and color across space and time. The course compares the human eye with the acute eyes of predatory birds and the compound eyes of insects. The course also describes exciting new optical technologies for correcting vision and for imaging the inside of the eye with unprecedented resolution, and how these technologies can help us understand and even cure diseases of the eye. The class is intended to be accessible to advanced undergraduate students, especially those majoring in optics, biomedical engineering, or brain and cognitive sciences, but is recommended for anyone with a curiosity about vision or an interest in biomedical applications of optics. The course also serves as an introduction to the study of vision for graduate students.

OPT 449. Instrumentation and Methods for Vision Research  
(Same as CVS 541)

This course describes the design, construction, and operation of optical instrumentation used in modern vision research. Various techniques for delivering stimuli to the retina, including Maxwellian view optics and CRT displays, are discussed. Methods of calibrating these systems are described in the context of a practical treatment of radiometry, photometry, and colorimetry. The course also covers optical techniques for monitoring the retina (optical coherence tomography), monitoring eye position (Purkinje eye tracking), and monitoring the brain (infrared reflectance imaging).

OPT 450. Polarization  
Prerequisites: OPT 441 and 461 or permission of instructor.

This course covers the fundamentals necessary to understand the behavior of fully and partially polarized light, and the significant range of applications and optical systems in which polarization is important. Topics include foundational electromagnetic theories of propagation and scattering, polarized plane waves, polarization eigenstates, Jones and Mueller calculii, ellipsometry, polarization in multilayers and gratings, principles of polarization ray-tracing, polarization effects in focusing and imaging, polarization metrology, and topics in polarization coherence.

452. Medical Imaging—Theory and Implementation  
(Same as ECE 452)

Physics and implementation of X-ray, ultrasonic, and MR imaging systems. Special attention is given to the Fourier transform relations and reconstruction algorithms of X-ray and ultrasonic-computer tomography, and MRI.

453. Quantum Optics and Quantum Information Lab  
This laboratory course exposes students to cutting-edge photon counting instrumentation and methods with applications ranging from quantum information to biotechnology and medicine. It is based on quantum information, the new exciting application of photon counting instrumentation. As much as wireless communication has impacted our daily life already, the abstract theory of quantum mechanics promises solutions to a series of problems with similar impact on the twenty-first century. Major topics are entanglement and Bells inequalities, single-photon interference, single-emitter confocal fluorescence microscopy, Hanbury Brown and Twiss correlations/photon antibunching. Photonic-based quantum computing and quantum cryptography are outlined in the course materials as possible applications of these concepts and tools.

456. Chemical Bonds: Molecules and Materials  
An introduction to the electronic structure of extended material systems from both a chemical bonding and a condensed matter physics perspective. The course discusses materials of all length scales from individual molecules to macroscopic three-dimensional crystals, but will focus on zero-, one-, and two-dimensional inorganic materials at the nanometer scale. Specific topics include semiconductor nanocrystals, quantum wires, carbon nanotubes, and conjugated polymers.

461. Physical Optics I  
Prerequisites: undergraduate electromagnetic theory, advanced calculus, linear algebra.

The principles of physical optics including diffraction and propagation based on Fourier transform theory; integral formulation of electromagnetic propagation; diffraction from apertures and scattering objects; applications to optics of Fourier transform theory; sampling expansions, impulse response, propagation through optical systems, imaging and transforming, optical transfer function, optical filtering, and selected topics of current research interest.

462. Physical Optics II: Electromagnetic Waves and Fourier Optics  
Prerequisites: undergraduate electromagnetic theory, advanced calculus, and vector analysis.

This course covers topics in electromagnetic theory that serve as a foundation for classical descriptions of many optical phenomena. A partial list of topics include review of Maxwell’s
equations, boundary conditions, and wave equations; polarization of light; crystal optics; vector, scalar, and Hertz potentials; radiation from accelerated charges; electric and magnetic dipole radiation; Lorentz atom description of the interaction of light with matter; scattering; and optical waveguides.

464. Physics and Application of Nanophotonic and Nanomechanical Devices
Prerequisites: ECE 230 or OPT 262 or 462, ECE 235/435 or OPT 226 or 468, OPT 223 or 412 or PHY 237 or 407.

This course aims to provide students with the understanding of fundamental principles governing optical and mechanical phenomena at micro/nanoscale level, with focus on current research advances on device level. The following topics are covered: fundamental concepts of micro/nanoscale optical cavities and mechanical resonators; various types of typical nanophotonic and nanomechanical structures; fabrication techniques; theoretical modeling methods and tools; typical experimental configurations; physics and application of optomechanical, quantum optical, and nonlinear optical phenomena at mesoscopic scale; state-of-the-art devices, and current research advances.

465. Principles of Lasers
Prerequisites: undergraduate electromagnetic theory and quantum mechanics.

This course provides an up-to-date knowledge of modern laser systems. Topics covered include quantum mechanical treatments to two-level atomic systems, optical gain, homogenous and inhomogenous broadening, laser resonators and their modes, Gaussian beams, cavity design, pumping schemes, rate equations, Q switching, mode-locking, and various gas, liquid, and solid-state lasers.

467. Nonlinear Optics
Prerequisites: OPT 461 or 462.

Fundamentals and applications of optical systems based on the nonlinear interaction of light with matter. Topics include mechanisms of optical nonlinearity, second-harmonic and sum- and difference-frequency generation, photonics and optical logic, optical self-action effects including self-focusing and optical soliton formation, optical phase conjugation, stimulated Brillouin and stimulated Raman scattering, and selection criteria of nonlinear optical materials.

468. Waveguide Optoelectronic Devices
This course covers the propagation and interactions in optical waveguides. Topics covered include the Goos-Haenchen effect; modes of the planar waveguide; coupled-mode theory; modes of the optical fiber; pulse broadening in optical fibers; coupling between guided-wave structures; waveguide devices such as semiconductor lasers, fiber lasers, and amplifiers, passive components, and electro-optics devices.

470. Biomedical Microscopy
This course covers the principles and practice of light microscopy, as applied to biological and medical questions. Topics include basic light microscopy, DIC, phase epifluorescence, confocal and multiphoton laser-scanning microscopy, and selected methods such as CARS, FRET, FRAP, FCS, etc.

476. Biomedical Optics
Prerequisite: basic knowledge of quantum mechanics, statistical mechanics, linear algebra, differential equations, and vector calculus. Open to graduate students and upper-level undergraduates (who usually enroll in OPT 276, with fewer homework problems).

Biomedical optics is the study of how light is used to study biological systems, to obtain medical information, and to perform clinical procedures. Major topics in this course include biomedical spectroscopy (absorption, fluorescence, Raman, and elastic scattering), propagation of photons in highly scattering media (such as tissue), and techniques for high-resolution imaging in biological media: confocal imaging, multiphoton imaging, and optical coherence tomography. (Fall, even years)

481. Technical Entrepreneurship
Presentations by guest speakers. The primary requirement for the course is the development of a business plan for a start-up that integrates the various organizational functions of a company. See website (www.optics.rochester.edu) for more information.

482. System Integration and Product Development
Prerequisites: OPT 425, 441, and 461, or permission of instructor.

This class explores the ISO 9000 product development process and illustrates how to use this process to develop both products and research systems that meet necessary specifications. The class uses systems such as video projectors, CD-ROM drives, barcode scanners, and scanning laser microscopes as examples to illustrate the various concepts.

491. Reading Course in Optics (MS)
Credit to be arranged
Supervised reading and study on topics beyond those covered in existing formal courses.

492. Special Topics
A lecture or seminar course on topics of current interest. Current listings available on the department website.

493. Master’s Essay
Supervised preparation of a master’s essay for Plan B candidates.

495. Research in Optics (MS)
Credit to be arranged

521. Optical Interactions in Solids
This course consists of a sequence of lectures on topics in solid-state physics, which are necessary to understand the operation of optoelectronic devices. To balance the course between theoretical and experimental topics, each lecture commences with a 15-minute overview of a specific experimental technique or
device that is related to the optical properties of solids. Lectures cover the following topics: optical constants of solids, electronic states, the role of lattice vibrations, a detailed look at optical transitions, and building devices.

528. Advanced Topics in Telecommunications
Prerequisites: OPT 461; OPT 428 recommended (but not required).

The course is designed to provide students with an understanding of the recent advances in the field of lightweight technology. The following topics are covered: dispersive and nonlinear effects in optical fibers; linear and nonlinear properties of fiber Bragg gratings, of fiber couplers, and of fiber interferometers, including Fabry-Perot resonators, nonlinear fiber-loop mirrors, Mach-Zehnder interferometers, different kinds of fiber amplifiers and lasers, pulse-compression techniques, design of modern fiber-optic communication systems, optical solitons, and their applications.

544. Advanced Lens Design
Prerequisite: OPT 444.

This course starts with a review of refractive optical design forms. The design of complex zoom lenses and multi-mirror reflective systems is discussed in detail starting with first principles. Other topics covered include optical design and materials for the ultraviolet and infrared wavelength bands, plastic optical systems, optomechanical design, tolerancing, sensitivity analysis, Monte Carlo analysis, environmental analysis, advanced optimization techniques such as user-defined and global optimization, ghost and stray light analysis, and illumination design. Students are required to complete two complex group design projects.

551. Introduction to Quantum Optics
(Same as PHY 531)
Prerequisite: OPT 412 or PHY 407/408 or permission of instructor.

An introduction to quantum and semiclassical radiation theory with special emphasis on resonant and near-resonant interactions between atoms and optical fields. Topics covered include field quantization, Weisskopf-Wigner and Jaynes-Cummings models, the optical Bloch equations, resonant pulse propagation, homogeneous and inhomogeneous broadening, adiabatic and non-adiabatic transitions, and dressed states.

552. Quantum Optics I
Prerequisite: OPT 551 or permission of instructor.

This course is a continuation of Quantum Electronics I in which the basic theory developed in the first semester is applied to atomic and molecular systems. The topics covered include resonance fluorescence, superfluorescence, saturation spectroscopy, stimulated Raman scattering, multiphoton ionization, and other spectroscopic techniques of current interest.

553. Quantum Optics III: Atom-Field Interactions
(Same as PHY 533)
Prerequisite: OPT 551 or PAS 531 or permission of instructor.

Topics covered include the resonant interaction of atoms and quantized fields including spontaneous emission, the Lamb shift, resonance fluorescence, the quantum regression and fluctuations-dissipation theorems, quantum states of the field including squeezed states, Schrödinger cat states and bi-photons, entanglement in atom-field interactions, multiphoton ionization and other strong field effects, and wave packet physics.

554. Advanced Topics in Quantum Optics
Prerequisite: OPT 412 or PHY 407/408 or permission of instructor.

Several professors from the Institute of Optics and the Department of Physics and Astronomy (Alonso, Bigelow, Boyd, Eberly, Howell, and Stroud) deliver a two-double lecture sequence as an overview of their current research interests in quantum optics. Both experimental and theoretical topics are discussed. In addition, students carry out 6-hour laboratory experiments on generation and characterization of single and entangled photons (Lukishova). Grades [S (satisfactory) or E (failure)] are based on the evaluation of a homework problem set for each section of the course.

561. Advanced Imaging
Prerequisite: OPT 461.

This course covers advanced topics in imaging, concentrating on computed imaging; Fourier-transform-based imaging; and unconventional imaging, with emphasis on imaging through aberrating media (particularly atmospheric turbulence), in mathematical depth. Topics are selected from the following: stellar (speckle, Michelson, and intensity) interferometry, wavefront sensing for adaptive optics, phase diversity; pupil-plane lensless laser imaging, including 2-D and 3-D digital holo-graphy, imaging correlography, and X-ray diffraction imaging; Lyot coronagraphy, Fourier telescope, Fourier-transform imaging spectroscopy, structured-illumination superresolution, optical coherence tomography, extended-depth-of-field imaging, and synthetic-aperture radar. Additional topics suggested by the students are considered. The course also explores image reconstruction and restoration algorithms associated with these imaging modalities, including phase retrieval, Wiener-Helstrom and maximum likelihood deconvolution, multiframe blind deconvolution, dealiasing, side-lobe reduction, and phase-error correction algorithms. A project plus term paper, exploring an advanced imaging topic in depth, including computer simulations (or laboratory experiments) and implementing the image formation or restoration algorithms, are required.

563. Statistical Optics
Prerequisites: OPT 461 and 462; students are encouraged to take PHY 404 concurrently.

564. Theory of Optoelectronic Systems
Prerequisite: OPT 461.
With a definite systems orientation, topics in diffraction theory, coherence, signal processing, detection theory, digital image processing, spatial and frequency domain filtering, and statistical optics are studied as they apply to systems for imaging, digital cameras, and remote sensing. Regular problem sets are assigned together with request-for-proposal (RFP) topics so that the advanced graduate students obtain experience in the technical aspects of preparing systems proposals. Students prepare a final oral presentation (no other final examinations) to brief the class on a topic related to the course material. The course is a continuation of OPT 461–462.

591. Reading Course in Optics (PhD)
Credit to be arranged
Supervised reading and study on topics beyond those covered in existing formal courses.

592. Nano-Optics
Prerequisites: advanced calculus and vector analysis, electromagnetic theory, and quantum mechanics.
Nano-optics is an emerging new field of study motivated by the rapid advance of nanoscience and technology. The course addresses the key issues of optics on the nano-meter scale. Among the topics are theory of strongly focused light, confocal and near-field optical microscopy, atomic decay rates in inhomogeneous environments, single molecule spectroscopy, and optical forces.

595. Research in Optics (PhD)
Credit to be arranged

596. Optics Colloquium
No credit
A series of talks on current research in optics, solid-state physics, and related fields. Speakers are visiting scientists, graduate students, and members of the faculty. Required each year of all graduate students in optics.

Interdisciplinary Master’s Programs

Arts, Sciences & Engineering in recognizing the diverse interests of students has developed and formalized interdisciplinary master’s programs. A standing committee of faculty* acts as a “department” and supervises the program requirements for its students.

Alternative Energy
Professors 1Chen, 1Chimowitz, 1Jorné, 3Li, 2Schroder, 5Sobelwski, 1Tang, 1Wu
Associate Professors 1Anthamatten, 2Krauss, 1Yates (Director)
Assistant Professor 1Shetopalous
Adjunct Assistant Professor †4Foster

This program is designed for graduate students with a bachelor’s degree in engineering or science who are interested in pursuing a technical career in alternative energy. Entering students must have completed two-semester courses in general chemistry, general physics, and calculus, in addition to one-semester courses in differential equations and thermodynamics, or their equivalents. Students deficient in these academic preparations are required to take bridging courses in addition to the degree requirements described below.

Degree Options and Requirements
The programs of study of all students must receive approval by their faculty advisors, the director of graduate studies in chemical engineering, and the dean of graduate studies in Arts, Sciences & Engineering. The Master of Science degree in alternative energy can be earned with Plan A (writing a thesis) or Plan B (not writing a thesis); the general requirements for these two options are described for existing Master of Science programs in Regulations and University Policies (see page 43). Plans A and B are available to both full- and part-time students. Full-time students receiving stipends from grants or contracts, however, are expected to write a thesis Plan A under the sponsoring faculty advisors’ supervision.

Master of Science with Thesis (Plan A)
Students in Plan A must earn a minimum of 30 credit hours, at least 18 of which should be attributed to formal 400-level courses. The balance of the credit-hour requirement can be satisfied through independent reading (no more than four credit hours) and thesis research (at least six credit hours), culminating in a master’s thesis.

* Primary appointments in another department
† Part-time
**Master of Science without Thesis (Plan B)**

Students in Plan B must earn a minimum of 32 credit hours of coursework acceptable as graduate credits, at least 24 of which should be attributed to formal 400-level courses identified and no more than 4 through independent reading. Students may opt for industrial internship (one credit hour), for which a final essay must be submitted as a part of their degree requirements. In addition to coursework and the essay, all Plan B students must pass a comprehensive oral examination as part of the degree requirements.

**Coursework Requirements**

To fulfill the credit-hour requirements, students should include a minimum of three core competency courses for Plan A, and at least four for Plan B, of which at least one must be selected from ERG 458, 460, 464, and 465. The courses identified below provide core competency in alternative energy, and the balance of the coursework requirement can be satisfied by taking technical electives listed as follows. With prior approval by the program director of graduate studies, equivalent graduate-level courses are accepted, and up to two undergraduate equivalents can be accommodated at three credit hours each.

**CORE COURSES**

**441. Advanced Transport Phenomenon**

This course acquaints the student with important topics in advanced transport phenomena (momentum, heat, and mass transport). Topics include laminar and turbulent flow, thermal conductivity and the energy equation, molecular mass transport and diffusion with heterogeneous and homogeneous chemical reactions. Focus is to develop physical understanding of principles discussed with emphasis on chemical engineering applications. In addition to the text, the student is exposed to classic and current literature in the field. (Fall)

**458. Electrochemical Engineering and Fuel Cells**

The course concentrates on presenting the principles of electrochemistry and electrochemical engineering, and the design considerations for the development of fuel cells capable of satisfying the projected performance of an electric car. The course is expected to prepare students for the challenges of energy conversion and storage and the environment in the twenty-first century. (Fall)

**460. Solar Cells**

This course introduces students to the basics of photovoltaic devices: physics of semiconductors; pn junctions; Schottky barriers; processes governing carrier generation, transport and recombination; analysis of solar cell efficiency; crystalline and thin-film solar cells, tandem structures, dye-sensitized and organic solar cells. Students learn about current photovoltaic technologies, including manufacturing processes, and also the economics of solar cells as an alternative energy source. Critical analysis of recent advances and key publications are a part of the coursework. (Fall)

**464. Biofuels**

An overview of science, technologies, and processes relating to biomass as an alternative energy source, including the biological and thermochemical approaches. (Fall)

**465. Thermochemical Biomass Conversion**

Conversion of biomass to liquid fuels and chemical feedstocks traditionally derived from petroleum. Production of jet fuel, gasoline, and diesel fuel via gasification, liquefaction, pyrolysis, aqueous phase reforming, and transesterification of a variety of biomass. Generation of chemical platforms in support of food, drug, pharmaceutical, and polymer industries. Green chemistry and engineering aimed to improve sustainability of chemical conversions of a plethora of key intermediates originating from biomass. Use of environmentally benign solvents—such as ionic liquids, water, and supercritical carbon dioxide—in place of organic solvents. Catalytic chemical reactions with ball milling, microwave irradiation, and sonochemistry using minimum catalysts and solvents while maximizing reaction rates and yields for ease of product isolation and purification. Microreactor technology to maximize heat and mass transfer rates, reaction yields and product selectivities, and to facilitate process control, optimization, and scale-up. (Spring)

**TECHNICAL ELECTIVES**

**413. Engineering of Soft Matter**

**430. Organic Electronics**

**454. Interfacial Engineering**

**469. Biotechnology and Bioengineering**

**480. Chemistry of Advanced Materials**

**485. Polymer Science and Engineering (CHE 482)**

**CHE 482. Processing Microelectronic Devices**

**CHM 456. Chemical Bonds: From Molecules to Materials**

**CHM 462. Biological Chemistry**
ECE 423. Semiconductor Devices

ME 451. Crystallography and X-Ray Diffraction

ME 481. Mechanical Properties of Solids (school approval pending)

PHY 420. Introduction to Condensed Matter Physics

Technical Entrepreneurship and Management (TEAM)

Vice Provost for Entrepreneurship and Professor *Moore
Senior Associate Dean *Hansen
Professors *Bocko, *Lambropoulos, *Thomas
Associate Professors *Anthamatten, *Ding, *McGrath, *Zavislan

The Center for Entrepreneurship administers the MS in Technical Entrepreneurship and Management (TEAM) Program, offered jointly by the Edmund A. Hajim School of Engineering and Applied Sciences and the Simon Graduate School of Business.

Overview of the MS in TEAM

The emphasis for the TEAM master’s program is to combine a graduate-level technical education at the Hajim School with entrepreneurial management coursework at the Simon School. It is recommended that students pursue a different engineering focus than their undergraduate major. TEAM prepares students for industry work in a variety of engineering, analyst, management, and “entrepreneurial” roles and outfits aspiring entrepreneurs with skills to launch an enterprise. The degree offers the following:

- Graduate-level courses in one of the following technical concentrations: (1) biomedical engineering, (2) chemical engineering, (3) computer science, (4) electrical and computer engineering, (5) energy and the environment, (6) mechanical engineering, (7) materials science, and (8) optics.
- Familiarity with the chosen technical discipline, fostered by an emphasis on critical thinking, creativity, and innovation, and an immersive educational and research environment.
- Exploration of general business through an analytical lens, with a focus on organizing and managing resources and ethics and leadership.
- Exposure to real-world applications, including the opportunity to commercialize University of Rochester patented technologies.
- Requirements: degree requirements as stated in Regulations and University Policies (see page 42), three core entrepreneurship (TEM) courses, three technical elective courses, one additional technical or entrepreneurship management elective, one semester-long practicum, and final comprehensive examination consisting of a written business plan and an oral presentation.

Admission

All applicants are required to submit the following materials along with the application: official transcripts; GRE or GMAT scores; three letters of recommendation; and a personal statement. In addition, applicants must submit a tentative technical concentration from one of the eight areas listed above. A bachelor’s degree, or equivalent, in engineering, applied sciences, or mathematics is required.

Those applicants whose native language is other than English are required to submit TOEFL or IELTS scores as well. Candidates must submit completed applications online at www.rochester.edu/team/apply by February 15. Supporting documents must be mailed to University of Rochester Center for Entrepreneurship, 1-211 Carol Simon Hall, P.O. Box 270360, Rochester, NY 14627-0360 or faxed to (585) 276-2357. For more information, please call (585) 276-3500 or visit www.rochester.edu/team.

REQUIRED ENTREPRENEURSHIP COURSES

401. Economics, Marketing, and Strategy Primer for Entrepreneurs

This course is designed to present fundamental concepts of microeconomics, marketing, and strategy, which will form the foundation for understanding the economic marketplace, and to provide the basis for assessing entrepreneurial opportunities. The course begins with a study of consumer and firm behavior and the resulting demand and supply conditions in individual markets. Factors that affect market structure, prices, output levels, firm profitability, and consumer welfare are addressed in this context. A critical question facing entrepreneurs and others developing new products or services is determining whether the market potential for a product justifies the investment. Building on the economic model, the course explores marketing issues, in particular the value proposition for new products. The course concludes with an examination of strategies for both the development and marketing of new products and services. Topics include strategies for market entry (stand alone, joint venture, licensing), distribution policies, pricing policies, and product positioning.

402. Accounting and Finance Primer for Entrepreneurs

This course is designed to present the fundamentals of financial accounting and financial analysis that serve as a foundation for concepts developed throughout subsequent courses in the entrepreneurship program. The objectives of this course are to enable participants to understand and productively use the principles of finance and accounting information to better structure business decisions. The accounting module presents skills required to interpret and analyze common financial statements and evaluate a company’s past performance and potential future performance. Specific topics of discussion include transaction analysis, cash vs. accrual accounting, financial statements, financial statement analysis, development of budgets and pro-forma financial...
statements, depreciation methodologies, and inventory methodologies. The financial module presents skills required to understand how companies make investment and financing decisions. Specific topics of discussion include calculation of net present values, an introduction to financial instruments, the tradeoff between risk and return in financial markets, capital budgeting and investment decision making, choosing an optimal capital structure, and using the weighted average cost of capital.

411. General Management of New Ventures

This course provides an opportunity to examine the management practices associated with technical innovation and new business development. The analysis of entrepreneurship is evaluated primarily from the perspective of a start-up venture that requires equity capital investment. Management issues discussed include organizational development, analysis of market opportunities, market engagement, financial planning and control, capitalization, sources of funds, the due-diligence process, and valuing the venture. Teams of three to four students collaborate in the preparation of a business plan. The course includes time for students to share business ideas and identify possible team members. Each team has a coach who is an experienced businessperson. The coach is available to provide feedback to the team.

440. Screening Technical Opportunities

This course provides a process used to quickly assess the commercial merits of raw technologies. The course focuses on the very earliest stage of concepts where information is greatly lacking and the time and money to research such answers is also limited. Students, in group format, parse through approximately 150 technologies that are available for licensing. These are provisional, pending, and issued patents based upon research conducted at the University of Rochester and held by the Office of Technology Transfer. Teams select and “thicken” two technologies of interest. Thickening involves a cursory evaluation based upon technical merit, early market indicators, human resource availability, and business challenges. Teams use a template to present the results of their investigation to a panel. Teams must state whether or not each technology is worthy to bring forward into the TEM 441: Practicum.

441. TEAM Practicum

In this class, students explore system engineering via the ISO 9000 product development process and illustrate how to use this process to develop both products and research systems that meet necessary specifications. The first eight weeks emphasize system integration including the development of the product development plans, partitioning of a system into subsystems, quantitative analysis of system performance, and the role of prototypes. The second half of the semester emphasizes the planning needed to take systems to manufacture. During the course, students prepare a product development plan on a project that was selected during TEM 440: Screening Technical Opportunities. The course is intended to be interactive. A portion of the classes are dedicated to “brain-storming” solutions to technical problems and formal design reviews, where the students review the project plans of other students.

ENTREPRENEURSHIP ELECTIVES

437. Technology Commercialization in Global Economy

This course introduces students to the topics of internationalization and globalization. It teaches students market considerations, business cultures, and foreign regulations.


This course introduces students to product development methodologies and function analysis. Topics covered include life cycle management, vendor management, customer needs, and innovation. Finally students develop a product development plan and ROI analysis.

Students may also take one graduate-level course from the Simon Graduate School of Business.

TECHNICAL COURSES

A complete list of technical courses in the eight offered concentrations can be found online at www.rochester.edu/team/program/technical.
Eastman School of Music

Administrative Officers

Douglas Lowry, MM
Joan and Martin Messinger Dean

Jamal J. Rossi, DMA
Executive Associate Dean

Donna Brink Fox, PhD
Associate Dean of Academic and Student Affairs

Marie Rolf, PhD
Associate Dean of Graduate Studies

Committee on Graduate Studies

Dean Rolf (Chair), Professors Azzara, Barr, Campbell, Cowdrick, Esse, Freitas, Grunow, Humpherys, Laitz, Lin, Liptak, Schindler, Temperley, Van Demark, Weinert, D. Ying

Faculty Offering Graduate Instruction

Natalya Antonova (Leningrad Conservatory)
Professor of Piano

Christopher Azzara, PhD (Rochester)
Professor of Music Education

Jean Barr, DMA (Southern California)
Professor of Accompanying and Chamber Music

John Beck, MM (Rochester)
Professor Emeritus of Percussion

Lynn Blakeslee, BM and Diploma (Curtis)
Professor of Violin

Bonita Boyd, BM (Rochester)
Professor of Flute

Kathleen Bride, MS (Juilliard)
Professor of Harp

Matthew Brown, PhD (Cornell)
Professor of Music Theory

Michael Burritt, MM (Rochester)
Professor of Percussion

Tony Caramia, MM (Fredonia)
Professor of Piano

Charles Castleman, MA (Pennsylvania)
Professor of Violin

Katherine Ciesinski, MM (Temple)
Professor of Voice

John Covach, PhD (Michigan)
Professor of Music Theory

Steven Daigle, MM (Florida State)
Professor of Opera

Harold Danko, BME (Youngstown)
Professor of Jazz Studies and Contemporary Media

Steven Doane, MM (SUNY, Stony Brook)
Professor of Violoncello

William Dobbins, MA (Kent State)
Professor of Jazz Studies and Contemporary Media

Jonathan Dunby, PhD (Leeds)
Professor of Music Theory

Donna Brink Fox, PhD (Ohio State)
Eisenhart Professor of Music Education

Nicholas Goluses, DMA (Manhattan)
Professor of Guitar

Richard Grunow, PhD (Michigan)
Professor of Music Education

Alan Harris, MM (Indiana)
Distinguished Professor of Violoncello

David Headlam, PhD (Michigan)
Professor of Music Theory

Benton Hess, BM (New England Conservatory)
Distinguished Professor of Voice

David Higgs, MM (Manhattan)
Professor of Organ
Douglas Humpherys, DMA (Rochester)
Professor of Piano

John Hunt, MM (Catholic)
Professor of Bassoon

Richard Killmer, DMA (Yale)
Professor of Oboe

Mikhail Kopelman, (Moscow Conservatory)
Professor of Violin

Ellen Koskoff, PhD (Pittsburgh)
Professor of Ethnomusicology

Kim Kowalke, PhD (Yale)
Professor of Music

Richard Killmer, DMA (Yale)
Professor of Oboe

Mikhail Kopelman, (Moscow Conservatory)
Professor of Violin

Ellen Koskoff, PhD (Pittsburgh)
Professor of Ethnomusicology

Kim Kowalke, PhD (Yale)
Professor of Music

Oleh Krysa, (Moscow Conservatory)
Professor of Violin

Peter Kurau, MA (Connecticut)
Professor of Horn

Steven Laitz, PhD (Rochester)
Professor of Music Theory

David Liptak, DMA (Rochester)
Professor of Composition

Ralph Locke, PhD (Chicago)
Professor of Musicology

Douglas Lowry, MM (Southern California)
Professor of Conducting and Ensembles

Patrick Macey, PhD (California, Berkeley)
Professor of Musicology

John Marcellus, DMA (Catholic)
Professor of Trombone

Elizabeth West Marvin, PhD (Rochester)
Professor of Music Theory

Robert McIver, DMA (West Virginia)
Professor of Voice

Honey Meconi, PhD (Harvard)
Professor of Musicology

Robert Morris, DMA (Michigan)
Professor of Composition

Paul O'Dette
Professor of Lute

Rebecca Penneys, Artist's Diploma (Indiana)
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Professor of Music Theory

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General Information

The Eastman School of Music offers graduate programs leading to the Master of Arts, Master of Music, Doctor of Musical Arts, and Doctor of Philosophy degrees. Detailed information concerning these degree programs is found in the Official Bulletin of the Eastman School of Music of the University of Rochester and the supplement to that bulletin. All programs are under the administrative supervision of the School’s graduate committees: the Graduate Research Committee and the Graduate Professional Committee.

The Degree Master of Arts

Candidates who matriculate for the Master of Arts degree may major in music composition, music education, musicology, ethnomusicology, music theory, or music theory pedagogy. The major in composition requires a thesis in the form of a major composition, to be accompanied by an analysis paper on a subject to be approved by the composition faculty. The programs of study in music education and in ethnomusicology require a written thesis or a field project, and candidates are expected to show marked ability in research. The major in music theory pedagogy requires a teaching recital.

The Degree Master of Music

Major fields in which the degree Master of Music may be taken are performance and literature (vocal or instrumental), music composition, music education, early music, jazz studies and contemporary media (performance or writing), conducting (choral or instrumental), opera (performance or stage directing), and piano accompanying and chamber music. Supplementing the prescribed coursework, the majors in performance and literature, early music, jazz studies and contemporary media, and opera (performance) require a public solo recital, and the major in piano accompanying and chamber music requires two such recitals. The major in composition requires a thesis in the form of an orchestral work or a large chamber work. Candidates majoring in music education do not write a thesis but must pass a comprehensive written examination upon completion of their work. The major in opera (stage directing) requires a final directing project.

The Degree Doctor of Philosophy

Programs leading to the degree Doctor of Philosophy in music offer concentration in composition, music education, musicology, or theory. Candidates may include in their programs up to 6 credit hours in applied music, especially when such credit forms a part of a prior master's degree. Candidates majoring in
composition present an extended work for either orchestra, chorus, or large chamber ensemble, accompanied by a research paper dealing with some historical, theoretical, or analytical aspect of music. Candidates majoring in music education, musicology, or theory present a written dissertation which is the result of original research and which is expected to constitute a distinct contribution to knowledge.

**The Degree Doctor of Musical Arts**

The degree Doctor of Musical Arts (DMA) is designed to represent high attainment in the practice of music, with emphasis on the arts of performance and teaching. The candidate may major in performance and literature, composition, conducting, early music, jazz studies and contemporary media, music education, or piano accompanying and chamber music. In addition to the prescribed series of courses, requirements include the preparation of an acceptable dissertation, doctoral essay, or several research papers in addition to 2–3 recitals and a lecture-recital. A candidate for this degree must be first of all a capable practitioner of his or her art. Only those who meet rigorous standards in the field of practical music will be accepted for candidacy.

**Graduate Awards**

Each year the Eastman School of Music makes provisions to give financial aid to a number of graduate students. These awards, which are made upon the recommendation of respective departments, are classified as teaching, research, departmental, or technical awards, depending on the type of service required. Graduate awards range in monetary value from partial tuition to full tuition plus stipend. To be recommended for a graduate award, an applicant must be accepted for graduate study and have special aptitude for teaching, research, performance, or composition. Awards are made for one year and may be renewed upon reapplication, at the Eastman School’s discretion.

**Courses of Graduate Instruction**

A complete listing of courses and course descriptions will be found in the supplement to the Official Bulletin of the Eastman School of Music of the University of Rochester, which may be obtained from the Director of Admissions, Eastman School of Music, 26 Gibbs Street, Rochester, New York 14604-2599.
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* Part-time
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Associate Professor of Microbiology and Immunology

Lizabeth M. Romanski, PhD (Cornell)
Associate Professor of Neurobiology and Anatomy and in the Center for Visual Science

Stanley Schaffer, MD (Sackler School of Medicine)
Associate Professor of Pediatrics and of Community and Preventive Medicine

Patricia J. Simpson-Haidaris, PhD (Notre Dame)
Associate Professor of Medicine, and of Pathology and Laboratory Medicine

Tristram Smith, PhD (California, Los Angeles)
Associate Professor of Pediatrics

Janet D. Sparks, PhD (Pennsylvania)
Associate Professor of Pathology and Laboratory Medicine

* Jenny Speice, PhD (Virginia Polytechnic)
Associate Professor of Psychiatry

Suzanne Y. Stevens, PhD (Indiana)
Associate Professor of Neurobiology and Anatomy and of Psychiatry

Toru Takimoto, PhD (Hokkaido, Japan)
Associate Professor of Microbiology and Immunology

Helene Temkin-Greener, PhD (Massachusetts)
Associate Professor of Community and Preventive Medicine

Sally W. Thurston, PhD (Harvard)
Associate Professor of Biostatistics and Computational Biology

Andy Yen-Tung Teng, DDS (Kaoshiung Medical College)
Associate Professor of Dentistry and of Microbiology and Immunology

Edwin Van Wijngaarden, PhD (Carolina, Chapel Hill)
Associate Professor of Community and Preventive Medicine

Peter Veazie, PhD (Minnesota)
Associate Professor of Community and Preventive Medicine

Dongwen Wang, PhD (Columbia)
Associate Professor of Biostatistics and Computational Biology and of Medical Informatics

Brian Ward, PhD (Illinois)
Associate Professor of Microbiology and Immunology

William H. Watson, PhD (Rosemead)
Associate Professor of Psychiatry and of Neurology

Joseph Wedekind, PhD (Wisconsin–Madison)
Associate Professor of Biochemistry and Biophysics

Terry Wright, PhD (Rochester)
Associate Professor of Pediatrics and of Microbiology and Immunology

Shuyuan Yeh, PhD (Wisconsin)
Associate Professor of Urology and of Pathology

Fay Young, MD (Harvard)
Associate Professor of Medicine, of Pediatrics, of Oncology, and of Microbiology and Immunology

Yi-Tao Yu, PhD (Case Western Reserve)
Associate Professor of Biochemistry and Biophysics

Wei-Ping Zeng, PhD (SUNY, Buffalo)
Research Associate Professor of Pathology and Laboratory Medicine

Hongwei Zhao, ScD (Harvard)
Associate Professor of Biostatistics and Computational Biology

Jiyoung Zhao, PhD (Iowa State)
Associate Professor of Biomedical Genetics

Michael Zuscik, PhD (Rochester)
Associate Professor of Orthopaedics

Robert Block, MD (UMDNJ)
Assistant Professor of Community and Preventive Medicine

Michael Elliott, PhD (Wake Forest)
Assistant Professor of Microbiology and Immunology

Changyong Feng, PhD (Rochester)
Assistant Professor of Biostatistics and Computational Biology

Alan Friedman, PhD (California, Santa Barbara)
Assistant Professor of Environmental Medicine

Angela Glading, PhD (Pittsburgh)
Assistant Professor of Pharmacology and Physiology and of Biomedical Engineering

Alan Grossfield, PhD (Johns Hopkins)
Assistant Professor of Biochemistry and Biophysics

Hua He, PhD (Rochester)
Assistant Professor of Biostatistics and Computational Biology

Susan H. Horwitz, PhD (Union Institute)
Assistant Professor of Psychiatry

Paul J. Kammermeier, PhD (Case Western Reserve)
Assistant Professor of Pharmacology and Physiology

Amy Kiernan, PhD (Boston)
Assistant Professor of Ophthalmology and Biomedical Genetics

David R. Kornack, PhD (Cornell)
Assistant Professor of Biostatistics and Computational Biology

Jill Lavigne, PhD (Rochester)
Assistant Professor of Psychiatry and of Community and Preventive Medicine

Jose Lemos, PhD (Brazil)
Assistant Professor of Microbiology and Immunology

Richard Libby, PhD (Boston)
Assistant Professor of Ophthalmology and Biomedical Genetics

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Assistant Professor of Medicine

Tansy Love, PhD (Iowa)
Assistant Professor of Biostatistics and Computational Biology

Luis Martinez-Sobrido, PhD (Spain)
Assistant Professor of Microbiology and Immunology

David Mathews, MD (Rochester)
Assistant Professor of Biochemistry and Biophysics

Helene McMurray, PhD (Rochester)
Assistant Professor of Genetics

Hongyu Miao, PhD (Rochester)
Assistant Professor of Biostatistics and Computational Biology

Joshua Munger, PhD (Chicago)
Assistant Professor of Biochemistry and Biophysics and of Microbiology and Immunology

Wendy J. Nilsen, PhD (Purdue)
Assistant Professor of Psychiatry and of Clinical and Social Psychology

Catherine Ovitt, PhD (Washington)
Assistant Professor of Biomedical Genetics

Ellen L. Poleshuck, PhD (Kent State)
Assistant Professor of Psychiatry and of Obstetrics and Gynecology

Chrystoph Proschel, PhD (LICR)
Assistant Professor of Biomedical Genetics

Xing Qiu, PhD (Rochester)
Assistant Professor of Biostatistics and Computational Biology

Peter Salzman, PhD (Stanford)
Assistant Professor of Biostatistics and Computational Biology

* Part-time
General Information

Graduate students in the School of Medicine and Dentistry are under the administrative supervision of the senior associate dean for graduate education. They may be enrolled in one of the following programs authorized for advanced degrees: biochemistry, biophysics, clinical investigations, dental sciences, epidemiology, genetics, health services research and policy, microbiology and immunology, neurobiology and anatomy, neuroscience, marriage and family therapy, pathology, pharmacology, physiology, public health, statistics, toxicology, and translational biomedical science. Both master’s and PhD degrees are offered, except in clinical investigations, dental sciences, marriage and family therapy, and public health, which offer only the master’s degree. The program in dental sciences, while not offering a PhD directly, sponsors PhD candidates in several preclinical departments for studies with a direct bearing on dentistry. The Department of Community and Preventive Medicine sponsors the Master of Science in Clinical Investigation, Master of Public Health degree program, and the PhD in epidemiology and health services research and policy.

The PhD program in one of the biomedical sciences, or combined with an MD, provides appropriate preparation for a career in teaching, and research in university, industry, and government. Four interdisciplinary programs are offered: genetics, neuroscience, pathology, and toxicology. The genetics program involves Medical Center faculty in conjunction with faculty in the biology and chemistry departments. In cooperation with the School of Medicine and Dentistry’s faculty, the College’s Departments of Brain and Cognitive Sciences, Computer Science, and the Center for Visual Science participate in the neuroscience program. The PhD programs in biology, chemistry, and biomedical engineering are based in corresponding departments in the College.

Students admitted into the Graduate Education in Biomedical Sciences program begin their studies in a training cluster, which serves as the route of admission to the PhD programs. Training clusters include biochemistry and molecular and cell biology; biophysics and structural biology; biological engineering, cardiovascular sciences, and cellular and molecular basis of medicine; genetics, genomics, and development; immunology, microbiology, and virology; neuroscience; pathways of human disease; and toxicology.

Students have the option to pursue doctoral research with more than 200 faculty members dedicated to excellence in biomedical research, providing them with an exceptionally diverse choice of research areas.

Graduate students in some programs are required to assist, for a minimal period, in the School of Medicine and Dentistry teaching program or in another significant teaching experience as part of their regular training.

Under present regulations, responsibility for the MS degree programs rests with the Committee on Graduate Studies of the School of Medicine and Dentistry and the senior associate dean for graduate education. The PhD programs are under the same aegis, but ultimate responsibility for approval of PhD degrees and general regulations rests with the University Council on Graduate Studies and the University dean of graduate studies.

PhD Degree

The PhD programs are operated according to the general regulations described under Regulations and University Policies Concerning Graduate Study. To promote program flexibility and maximal individual attention, students in the School of Medicine and Dentistry plan their PhD programs with an advisory committee consisting of at least four members: two full-time members of the rank of assistant professor or higher from the candidate’s major department (these faculty must have a primary appointment in the candidate’s major department), one full-time faculty member assistant professor or higher from a department other than the candidate’s major department (usually referred to as the outside reader), and at least one representative of another department in either the medical school or the River Campus colleges. This committee also administers the qualifying examination, approves the thesis outline, and certifies eligibility for candidacy to the senior associate dean for graduate education.

Each PhD candidate must submit a completed program of study within two years of initial registration in graduate studies. For School of Medicine and Dentistry departments the program of study must have the approval of the student’s faculty advisor, the department or program chair, the members of his or her advisory committee, and the senior associate dean for graduate education.

Each student must have an annual research progress conference, the first being held no later than one year after the qualifying exam. At this time the thesis advisory committee will assess the research progress and thesis content as well as the projected finishing date of the student. A report that this has occurred is to be sent by the research advisor to the senior associate dean for graduate education by June 30.

MS Degree

Departments offer the MS degree under Plan A (i.e., with research thesis) and/or under Plan B.

Plan A usually requires 18 months to two years to complete the coursework and an adequate thesis, although the actual academic requirement in most programs is only 30 credit hours. The usual requirement of 18 hours of correlated coursework of
MD/PhD and MD/MS Programs

Students especially interested in a program leading to both the MD and the PhD degrees may apply for the combined degree program. The fields in which the PhD degree is most likely to be obtained in the joint program at present are biochemistry, biology,† biomedical engineering, † biophysics, chemistry, † genetics, epidemiology, health services research and policy, microbiology and immunology, neurobiology and anatomy, neuroscience, pathology, pharmaco- logy, physiology, statistics, and toxicology. Areas of the social sciences and business management of particular pertinence to medicine have been developed for an MD/MS degree and are available on an ad hoc basis for MD/PhD studies.

Admission to the combined degree program ordinarily is by joint application to the MD and PhD programs; however, this may be after a year or two of study as either a graduate student or a medical student. The candidate must be acceptable as both a medical and a graduate student before he or she can be fully matriculated in the combined degree program. The MD/PhD curriculum is unique; the distinctive requirements for each degree are preserved, however, the time required is less than the two degrees if taken in sequence. The MS and M.P.H. degrees can also be combined with the MD by use of the special programs in the areas of health care delivery (master’s in public health, systems analysis, business administration, etc.).

Transfer Credit

Of the School of Medicine and Dentistry’s minimum required 120 credit hours for the Doctor of Philosophy degree, no more than 30 credit hours may be accepted as transfer credit for work previously taken at the University of Rochester or at another university.

Of the School of Medicine and Dentistry’s minimum required 30 credit hours for the master’s degree, no more than 10 credit hours may be accepted as transfer credit for work previously taken at the University of Rochester or another university.

All transfer hours, whether taken at the University of Rochester or at another university, must be approved by the cluster/program director and the course director. The senior associate dean for graduate education will make the final determination of transfer hours.

Work taken prior to matriculation in a graduate degree program is classified as possible transfer work. The credit-hour limit may be accepted toward degree requirements if the subjects taken form an integral part of the proposed program of study and if taken within five years of the date of matriculation with a grade of B or higher as interpreted in this University. Petition for transfer credit must be made at the time of matriculation.

Permission to take work at another institution for transfer credit after matriculation in a graduate program must be approved in advance by the cluster/program director, course director, and the senior associate dean for graduate education.

Graduate Student Society

All graduate students in the School of Medicine and Dentistry are automatically members of the Graduate Student Society. This organization represents the graduate students of the School of Medicine and Dentistry in all aspects of student life, except those pertaining directly to individual progress in the academic program. Officers are elected each year, and there is representation to the Council of the Society by each department. In addition to acting as a clearinghouse for problems in graduate student life, the Society sponsors social functions, seminars, and lectures to promote cohesiveness and understanding among graduate students and sends a representative to meetings of the Committee on Graduate Studies and other groups involved in graduate student life. The Graduate Student Society receives mail at Box 355.

* In the School of Arts and Sciences; see announcement in this bulletin.
† In the Hajim School of Engineering and Applied Sciences; see announcement in this bulletin.
Biochemistry and Biophysics

Associate Professors *Bulger, *Butler, Goldstein, Grayhack, Kielkopf, Mathews, Wedekind, Yu
Assistant Professors Ermolenko, Grossfield, Munger
Professors Emeriti Gunter, Hilf, Kimmich, Lawrence, Senior, Sherman

BIOCHEMISTRY DEGREE PROGRAMS

The Department of Biochemistry and Biophysics offers programs of study leading to the MS (Plan A and Plan B) and PhD degrees in biochemistry. Research areas include enzyme mechanisms; protein chemistry; DNA replication, repair, and recombination; RNA processing; protein synthesis; computational biology; molecular biology and genetics; functional proteomics; gene expression and regulation; cell growth regulation; chromatin structure and function; structural biology; virology; molecular endocrinology; bioenergetics; membrane proteins, receptors and signal transduction; glycoproteins; oncology and oncogenes; and molecular basis of human disease. The application of chemistry to biological systems attracts students with academic backgrounds in biology and/or chemistry. Required coursework is kept to a minimum, allowing for development of individual programs of study appropriate to the students’ preparation and interests. Students are encouraged to choose from the numerous courses and seminars offered through the various departments in the School of Medicine and Dentistry and the Department of Biotechnology in the College. The qualifying examination for the PhD is generally completed by the end of the fifth semester in residence.

Requirements

Core Courses (required for all programs of study): IND 408 (Advanced Biochemistry); IND 409 (Cell Biology); IND 410 (Molecular Biology and Genetics); IND 501 (Ethics in Research); BCH 412 (Advanced Topics in Biological Macromolecules); BCH 501/502 (Seminars in Biochemistry); BCH 495 or 595 (MS or PhD Research).

Elective Courses (suggested but not limited to): BIO 402 (Molecular Biology); BIO 415 (Molecular Biology of Cell Signaling); BIO 420 (Advanced Cell Biology); BIO 426 (Developmental Biology); BPH 509 (Molecular Biophysics); GEN 507 (Advanced Genetics); IND 407 (Structure and Function of Cell Organelles); IND 443 (Eukaryotic Gene Organization and Expression); MBI 456 (General Virology); MBI 473 (Immunology); MBI 421 (Microbial Genetics); PHP 403/404 (Pharmacology and Physiology: A Disease-Based Approach I/II); PTH 507 (Cancer Biology). In addition, numerous seminar courses including BCH 570 (Chromatin and Transcription in Higher Eukaryotes) are recommended.

MS Program (Plan A)

The MS degree is awarded upon completion of at least 30 hours of credits that include required core courses (IND 408, 409, 410, 501, BCH 412) and approved electives. In addition, the student must defend a thesis developed from an independent research project accomplished under the supervision of a faculty member in the Department of Biochemistry and Biophysics.

MS Program (Plan B) and Qualifying Examination

Upon completion of the required coursework, a research proposal is written that serves as the basis for determining the potential of the student for independent thought and his or her comprehension of the general field and perspective for exploiting a relevant problem in a scientifically sound manner. The student completes the requirements for a Plan B master’s degree upon successfully passing this qualifying examination.

PhD Program

Students admitted to the PhD program choose a laboratory and advisor at the end of their first year of study after completing at least three laboratory rotations. PhD students are required to work as Teaching Assistants for one semester and pass the qualifying examination in their third year of study. Students are also required to make at least six research presentations in approved seminar courses or seminar series during their course of study.

IND 408. Advanced Biochemistry
Prerequisite: a one-semester introductory course in biochemistry or equivalent.
Credit—five hours

Designed primarily for graduate students. Eighty-minute lectures cover topics in modern biochemistry including analysis of protein and domain structure by classical and modern methods, including mass spectrometry, NMR, X-ray crystallography, and other biophysical techniques; protein–ligand and protein–protein interactions; enzyme kinetics and catalytic mechanisms; and cellular energy production and utilization. In addition, workshops are held once a week, during which time selected papers from the literature are discussed. (Fall)

IND 409. Cell Biology
Credit—four hours

This course is intended primarily for first-year graduate students with some previous coursework in cell biology. One-hour lectures include discussion of specific modern topics, including cell cycle and its breakdown during cancer and apoptosis; cytoskeleton; intracellular compartments and protein sorting; signal transduction and cell-cell communication; membrane structure and transport. In addition to the lectures, weekly interactive journal-club-style sessions explore the current cell biology literature. (Fall)
IND 410. Molecular Biology and Genetics  
**Credit—one hour**

This course is designed primarily for graduate students. One-hour lectures cover modern topics of interest, including DNA replication; DNA repair and mutagenesis; regulation of RNA transcription in eukaryotes; RNA processing, and protein translation. Emphasis is placed on both biochemical and genetic approaches to the study of these problems. Special additional topics include genomics as an approach to regulation and mammalian genetic techniques of analysis. (Spring)

BCH 412. Advanced Topics in Biological Macromolecules  
**Prerequisite: IND 408 or an equivalent biochemistry course.  
Credit—five hours**

An advanced biochemistry lecture course intended for senior undergraduates and graduate students. Topics include DNA structure; RNA structure and catalysis; nucleic acid-protein interactions; X-ray crystallography; NMR spectroscopy, protein folding, molecular chaperones, membrane proteins, post-translational modifications of proteins, ATPases, G protein and function, protein-protein interactions, proteases and cascade reaction pathways. (Spring)

BCH 491. MS Reading  
**Credit to be arranged**

BCH 493. MS Essay  
**Credit to be arranged**

BCH 495. MS Research  
**Credit to be arranged**

BCH 501/502. Seminars in Biochemistry  
**Prerequisite: BCH 401.  
Credit—one hour per term**

Seminar courses are given each semester. Continuous registration is required of all graduate students in biochemistry. Seminars are presented by PhD students and include topics in the areas of proteins, enzymes, nucleic acids, lipids, metabolic regulation, hormone action, biochemical genetics, physical biochemistry, membrane biochemistry, developmental biochemistry, and neurochemistry. (Fall and Spring)

BCH 515. Critical Thinking in Research Science  
**Credit—one hour**

Students present a history of the experimental work leading to their research project. The history includes a selection of published and unpublished work from their advisor’s lab and other labs in the same field that provides a rationale for undertaking the project. Students conclude with a report of their own published and preliminary data. The focus throughout is on interpreting experimental data and engaging student interactions. (Fall and Spring)

BCH 517. Cellular and Molecular Sciences  
**Credit—one hour**

This course promotes understanding of seminars given in the weekly Department of Biochemistry and Biophysics seminar series. Students attend at least 60 percent of the presentations in the Department of Biochemistry and Biophysics Invited Speaker Seminar Series during the semester. In addition, instructors and students select speakers (one-third of the speakers in the series), and read 2–3 publications (suggested by the speaker) in depth. Students then present these papers to the rest of the class, the instructors, and the speaker’s faculty host in a journal club setting prior to the speaker’s arrival. Finally, students attend a post-seminar class with the selected speaker, in which they ask questions related to the papers and to the topic of the seminar. (Fall and Spring)

BCH 570. Chromatin and Transcription in Higher Eukaryotes  
**Credit—two hours**

A literature-based course meeting once per week (two hours/session) where students read and discuss recent papers on selected issues relating to the regulation of gene expression in higher eukaryotes. The purpose is to familiarize students with a variety of contemporary research fields and methodologies through student-led discussions of current publications in the field. Papers are chosen by the instructor and focus on transcription regulatory mechanisms related to transcription factors and coactivators, the role of histone posttranslational modifications and other aspects of chromatin structure. (Spring, odd years)

BCH 593. Special Topics in Biochemistry  
**Credit to be arranged**

Directed studies in the field of biochemistry, supervised by a senior faculty member and organized to meet the needs of individuals or small groups of graduate students. May involve supervised readings, laboratory exercises, or organized discussions.

BCH 595. Research  
**Credit to be arranged**

Research centers around the following problems: regulation of lipid metabolism, structure and function of cell membranes, cell surface glycoproteins, physical chemistry of hemoproteins, biological energetics, structure of ATPases, hormonal regulation of mammary tissue and mammary tumors, hormone receptors, regulation of protein biosynthesis, DNA synthesis and repair, molecular genetics, and human diseases.

**BIOPHYSICS DEGREE PROGRAM**

The PhD program in biophysics teaches students how to employ the methods of mathematics, physics, chemistry, and biology in biomedical research. It emphasizes the use of physics, physical chemistry, and computational approaches to understand how living organisms work at a molecular level. This interdisciplinary program is administered by faculty from a variety of departments: biochemistry and biophysics, pharmacology and physiology, and radiology in the School of Medicine and Dentistry; biomedical engineering, chemistry, and the Institute of Optics in the College. Collectively, this group of faculty and their students form the Biophysics, Structural and Computational Biology (BSCB) program.
BSCB has a variety of state-of-the-art facilities available for students. They include 600, 500, and 400 MHz NMR spectrometers, a macromolecular X-ray crystallography laboratory, 2 EPR spectrometers, computer workstations for molecular graphics and structure calculations, a confocal microscope, and confocal fluorescence imaging system. In addition, laboratories are well equipped for modern biochemistry and molecular biology.

Students enter the program with a wide range of backgrounds. The most common backgrounds are physics or chemistry but engineering, biology, biochemistry, and mathematics majors also enter the program. The program specializes in bringing students from the physical/chemical sciences to a high level of proficiency in the biological sciences and teaching the more biologically trained students how to apply the tools of biophysics in biomedical research. Financial assistance is provided to all students.

The curriculum consists of core course requirements, general seminar and distribution requirements, elective courses, and laboratory rotations. The core courses include Molecular Biophysics, Advanced Biochemistry, Cell Biology, Molecular Biology and Genetics, and Methods in Structural Biology. The goal is to provide a balanced set of courses that brings the candidate to the forefront of current knowledge in the selected area while providing general familiarity in related fields. All first-year students are required to complete three laboratory rotations during the first year, one of which must be with a member of the Biophysics, Structural and Computational Biology program faculty. Participation in seminar programs is an important part of the graduate education experience and remains a component of the experience throughout residence.

Formal graduate course requirements generally are fulfilled within the first two years in residence. PhD thesis advisors are generally selected by the end of the second semester in residence and research on the thesis problem generally begins at the end of the first year. A first-year written and oral examination and a second-year written and oral examination comprise the qualifying examination for the PhD and are generally completed by the end of the fifth semester in residence.

**BPH 402. Mathematical Methods of Physiology and Medicine**  
*Prerequisite: elementary calculus.  
*Credit—three hours*

Computer modeling, mathematical description of biological and physical systems, analytical and numerical solutions of differential equations, Laplace transforms, Fourier series, partial derivatives. Calculus is reviewed as needed. There are a number of short computer laboratory sessions. (Fall)

**BPH 403. Mathematics for Molecular Biophysics**  
*Credit—three hours*

Wave motion, Fourier Series and complex representation, Fourier transforms, delta functions, analysis of scattering, repetitive structures, intensity, Maxwell’s equations, electromagnetic forces, spin, angular momentum and magnetic moment, Bloch equations, spectra, absorption and dispersion, vector analysis, partial differential equations, and interatomic forces. (Fall)

**BPH 408. Mathematical Methods of Biophysics**  
*Prerequisites: BPH 403 or its equivalent, and permission of instructor.  
*Credit—four hours*

Advanced mathematical techniques applied to problems of classical physics, biophysics, and three-dimensional image reconstruction. Electromagnetic theory, potential calculations, Green’s functions, properties of waves, calculus of variations, Fourier transforms, tomography, two-dimensional signal filters, NMR theory. Additional topics chosen by students.

**BPH 411. Methods in Structural Biology**  
*Prerequisites: calculus-based physics, BPH 403, 408, or permission of the course director.  
*Credit—five hours*

An introduction to the theory and practical application of several major techniques used in the structural characterization of biological macromolecules. These methods include X-ray crystallography, Small Angle X-ray Scattering, Spectroscopic and Calorimetric Techniques, NMR and Comparative Modeling. The goal is to enable nonspecialists to become conversant in the language and principles of the field, as well as to understand the strengths and limitations of various techniques. This course is a prerequisite to the literature-based course BPH 592, Advanced Topics in Biomolecular Diffraction and Scattering. Nonmajors should also consider BCH 412, Advanced Topics in Biological Macromolecules. (Spring, even years)

**BPH 509. Molecular Biophysics**  
*Prerequisite: calculus-based physics; permission of course coordinator.  
*Credit—five hours*

This course is designed to show how physical concepts and techniques are used to explore and understand biological phenomena. A major portion of the term focuses on thermodynamics of biological molecules and system and includes an in-depth exploration of computational biology methods for studying thermodynamics. Students are expected to have had basic courses in physics, chemistry, and biology, with an in-depth background in at least one of these areas. Students not in the biophysics program should consult the course coordinator before registering. (Spring, odd years)

**BPH 571/572. Biophysics Seminars**  
*Credit—one hour each*

A student seminar course is offered each semester and continuous registration is required of all graduate students in biophysics. Seminars are presented by PhD students and include topics relevant to the interests of the department.

**BPH 574/580. Specialty Seminars**  
*Credit—one or two hours each*

Specialty seminars are offered by faculty as interest and time permit.
**BPH 591. PhD Reading Course**  
*Credit to be arranged*

**BPH 592. Special Topics in Biophysics**  
*Credit—two hours*  
Special topics courses are offered each year that examine different aspects of biophysics in considerable depth.

**BPH 592. Special Topics in Biomolecular Diffraction and Scattering**  
*Prerequisites: BPH 402/BPH 403 and either BCH 412 or BPH 411 (or permission of the instructors).*  
*Credit—one hour*  
A current survey of the literature chosen by the course instructors that discusses macromolecular structure with an emphasis on protein/RNA taxonomy and folding, as well as the mathematical and physical principles of diffraction and scattering. Each student presents a paper to the group for discussion and analysis. The goal of this class is to help students make cogent connections between theory and practice in the field.

**BPH 595. PhD Research**  
*Credit to be arranged*  
The fields open for dissertation research are listed in the preceding general description for each degree program. Laboratory space and equipment are available in sufficient variety and depth to accommodate a large range of research interests.

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**Biostatistics and Computational Biology**

Professors *Hall, Liang, McDermott, Oakes, Strawderman (Chair), Tu, Wu*  
Associate Professors Almudevar, Beck, Huang, Hyrien, Peterson, Thurston, Wang  
Assistant Professors Feng, He, Love, Miao, Qiu, Salzman  
Joint Appointments: Professors Fisher, Mathews, Mudholkar, Sharma

The Department of Biostatistics and Computational Biology offers programs leading to the Doctor of Philosophy, Master of Arts, and Master of Science degrees. The department conducts a program of teaching and research in statistical theory and statistical methodology oriented toward the health sciences. Department faculty have research interests and expertise in virtually all areas of modern theoretical and applied statistics. Faculty are involved in wide-ranging collaborative activity with basic science and clinical departments in the School of Medicine and Dentistry. This environment is ideally suited for training in research in statistical methodology, collaborative research, and consulting.

The curriculum is designed to provide students with a thorough grounding in statistical theory, which provides the necessary foundation for the successful conduct of research in statistical methodology. Included are core courses in probability, stochastic processes, statistical inference, large sample theory, and Bayesian inference. The curriculum also provides students with an appreciation for applied problems in biomedical research and the skills necessary to succeed in collaborative research environments. Core courses focused on applications include Applied Linear Regression, Categorical Data Analysis, and Design of Clinical Trials, in addition to formal training in the use of statistical software. Additional core courses including Linear Models, Generalized Linear Models, Survival Analysis, and Analysis of Longitudinal and Dependent Data provide a mix of theory and application. Several elective courses are also offered. An important goal is to produce graduates with a command of technical skills and the ability and experience to use them appropriately.

Department faculty provide instruction to Medical Center faculty, fellows, postdoctoral trainees, and graduate students from basic science and clinical departments through a sequence of courses in biostatistical methods and clinical trial design (BST 463, 464, 465, 466). Doctoral students serve as teaching assistants in these courses during the first two years of study. Training grants in Environmental Health Biostatistics (funded by the National Institute of Environmental Health Sciences [NIEHS]) and Biostatistics for HIV/AIDS (funded by the National Institute of Allergy and Infectious Diseases [NIAID]) help support predoctoral and postdoctoral training.

* Part-time
PhD Degrees

Program for the Degree of Doctor of Philosophy in Statistics

The department administers the doctoral program in statistics. The department interprets the term "statistics" very broadly. The program permits specialization in probability, statistical theory and analysis, biostatistics, and interdisciplinary areas of application. Students have opportunities for supervised teaching and supervised consulting experience, requiring approximately 12 to 15 hours of effort per week.

A candidate for admission to the PhD program should have a background in college mathematics, including a year of advanced calculus or mathematical analysis (similar to MTH 265, 266), a course in linear and/or matrix algebra, and a year of probability and statistics (similar to STT 201, 203). A course in statistical methods is also recommended; however, promising students may make up deficiencies after matriculation. While some background in biology may be helpful for pursuing certain avenues of research, it is not required for admission to the program.

Doctoral students are expected to attain some competence in each of the following (overlapping) areas: I. statistical inference; II. statistical analysis (theory and methods); III. probability and stochastic processes. In addition, each student is expected to qualify at a more advanced level in two areas, designated major and minor. Minor areas, in addition to those three above, include IV. mathematics; V. epidemiology; VI. biostatistics; and VII. a specific field of application, such as econometrics, psychometrics, computer science, genetics, computational biology, engineering, etc. Students are required to acquire some proficiency in statistical computation, using at least one high-level language and several statistical packages. There is no formal specific language requirement, but students undertaking certain areas of research may find it necessary to undertake appropriate language study.

Students are required to take a minimum of 16 formal courses, including:

1. Basic courses: at least two courses in each of the areas I, II, and III and at least three in areas IV–VII combined.
2. Major area: at least three additional courses (12 credits), ordinarily at the 500 level, in one of the areas I–III (or IV–VII with permission).
3. Minor area: at least two additional courses in another one of the seven areas.

Beginning students should expect to spend all of their first year, most of their second year, and some of their third year taking formal courses. This includes a minimum of six semesters of BST 497, a one-credit seminar course designed to give students extensive practice in searching the statistical literature and preparing and delivering presentations. The balance of time is spent on reading and research. Students entering with advanced training in statistics may transfer credits at the discretion of their advisors and in accordance with University policy. A typical program for an entering student without previous advanced training is as follows:

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<tr>
<th>Year 1: Fall</th>
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<th>Year 1: Summer</th>
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<tr>
<td>BST 401 (4 credits)</td>
<td>BST 413 (4 credits)</td>
<td>BST 477 (0 credits)</td>
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<tr>
<td>BST 411 (4 credits)</td>
<td>BST 426 (4 credits)</td>
<td>BST 478 (0 credits)</td>
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<td>BST 464 (4 credits)</td>
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<td>BST 540 (2 credits)</td>
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<td>IND 501 (1 credit)</td>
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<th>Year 2: Fall</th>
<th>Year 2: Spring</th>
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<tr>
<td>BST 402 (4 credits)</td>
<td>BST 412 (4 credits)</td>
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<td>BST 479 (4 credits)</td>
<td>BST 512 (4 credits)</td>
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<td>BST 531 (4 credits)</td>
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<td>BST 497 (1 credit)</td>
<td>BST 497 (1 credit)</td>
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<tr>
<td>BST 590 (3 credits)</td>
<td>BST 591 (3 credits)</td>
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Year 3+

Mostly reading and research, with some 400-level (e.g., BST 452 or 465) and 500-level courses.

Notes

1. BST 497, Seminar in Statistical Literature (1 credit), is offered every semester. Topics covered vary. PhD students are required to register for at least six semesters.
2. Training in the use of statistical software (BST 477/478) is offered during the first six weeks of the summer as a computing rotation (no formal credit).
3. All PhD students are required to have at least four credits of supervised teaching and/or supervised consulting (BST 590, 592).
4. All students in the doctoral program are required to take IND 501, Ethics and Professional Integrity in Research (1 credit), in their first semester in the program.
5. Usually in Year 2, students begin exploring potential research topics by taking reading courses with faculty (BST 591). The structure, content, and number of credit hours for these courses are flexible and determined by mutual agreement between the students and faculty member.
6. Advanced courses listed as BST 511, 512, 550, or 570, for varying numbers of credits, are offered depending on interests of students and instructors. Recent examples include:
   - Permutation Tests
   - Frailty Models in Survival Analysis
   - Causal Inference
   - Advanced Topics in Object Data Analysis
   - Time Series
   - Introduction to ROC Methodology
   - Smoothing Methods
   - High-Dimensional Data Analysis
   - Statistical Inference Under Order Restrictions
   - Monte Carlo Methods and Modeling of Biomedical Dynamic Systems
   - The Bootstrap, The Jackknife, and Resampling Methods
   - Advanced Bayesian Inference with an Emphasis on Computation
Students also have the option of taking relevant courses that are offered through other doctoral programs at the University, such as Mathematics (e.g., MTH 471—Real Analysis), Epidemiology (e.g., PM 416—Epidemiologic Methods), and Health Services Research (e.g., PM 484—Cost-Effectiveness Research).

These requirements are to be interpreted as guidelines, rather than as regulations. A balanced program is worked out with the student's advisor and the graduate advisor. The examination requirement consists of:

1. Written examination in two parts. The basic part covers basic material in areas I–III, based on undergraduate preparation and some of the first-year graduate courses. It is taken after one year of study. The advanced part covers advanced material from two to three core courses in each of areas I–III taken during the first two years of graduate study. This part is usually taken after two years of study.
2. Qualifying examination (oral) on the general area of proposed research and other topics as necessary.
3. Final examination on the completed dissertation.

The dissertation will consist of substantial scholarly contribution, worthy of publication, in one of the areas I–III or in any other area approved by the faculty committee.

Considerations for Students in the MD/PhD Program

Students admitted to the MD/PhD program follow essentially the same course of study as students in the PhD program, except that coursework in statistics begins during the fall of the third year in the program. During the first year, students spend three months (June–August) with a mentor to begin the process of orientation toward research in statistical methodology. This may be implemented either as an informal (noncredit) reading course or as involvement in an applied project that may motivate a methodological research problem. This is repeated during the second year of the program (March–August) just prior to the start of coursework. The main goals of these interactions are to provide the student some insight regarding the process of research in statistical methodology and to facilitate the process of choosing a research advisor.

Master's Degrees

Program for the Master of Arts Degree in Statistics

The requirements for entry into the MA program are the same as those for entry into the PhD program. The MA degree requires satisfactory completion of at least 32 credits and a final examination (the basic part of examination requirement (1) above or an oral examination); no thesis is required. Of the 32 credits, at least 24 must be in departmental courses primarily at the 400 level or above. All three areas (I–III above) must be represented. Appropriate substitutions may be made as long as the spirit (distribution and level) of the requirements is met. The program must also include at least one semester of BST 497. A balanced program is worked out with the student's advisor.

Students in the PhD program receive an MA degree upon satisfactory completion of the requirements for this degree (typically during the second year of graduate study).

Program for the Master of Science Degree in Medical Statistics

The MS program in medical statistics is primarily intended for students who wish to follow careers in health-related professions such as those in the pharmaceutical industry and biomedical or clinical research organizations. For entry into the program, three semesters of calculus, a course in linear algebra (similar to MTH 165), a course in probability (similar to STT 201), a course in mathematical statistics (similar to STT 203), and a course in applied statistics (similar to STT 212) are required.

The master's program in medical statistics consists of one core year (two semesters) of coursework as well as an internship/applied project (BST 493), which is normally taken in the summer after the core program. There are no thesis or language requirements. The degree requires 32 credit hours consisting of all the 400-level courses listed below; substitutions may be made with approval of the faculty program advisor. A comprehensive oral examination to determine the student's qualifications for the MS degree will be administered upon completion of coursework and the internship/applied project.

A typical program for an entering student without previous advanced training is as follows:

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<th>Fall</th>
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<tr>
<td>BST 411 (4 credits)</td>
<td>BST 422 (2 credits)</td>
<td>BST 493 (8 credits)</td>
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<td>BST 421 (4 credits)</td>
<td>BST 441 (2 credits)</td>
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<td>BST 464 (4 credits)</td>
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<td>BST 466 (4 credits)</td>
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The following courses are offered; see also offerings in mathematics (including the program in statistics). Unless otherwise noted all courses carry four credit hours.

401. Probability Theory
Prerequisite: MTH 265 or equivalent (or permission).

Probability spaces; random variables; independence; distributions; expectation; characteristic functions and inversion theorems; convergence; laws of large numbers; central limit theorem.

402. Stochastic Processes
Prerequisite: BST 401.

Markov chains; birth-death processes; random walks; renewal theory; Poisson processes; Brownian motion; branching processes; martingales; with applications.

411. Statistical Inference
Prerequisites: STT 203 and MTH 265 or equivalent.

Probability distributions, transformations and sampling distributions; statistical models; estimation, hypothesis testing, and confidence intervals for parametric models; introduction to large-sample methods.

412. Large-Sample Theory and Methods
Prerequisites: BST 401 and BST 411.

Weak convergence; asymptotic linearity; local analysis; large sample estimation, maximum likelihood estimation and M-estimation; Wald, likelihood ratio, and score tests; confidence regions; nuisance parameters; efficiency; multinomial chi-square tests.
413. Bayesian Inference  
Prerequisite: BST 411.

Posterior distributions for single and multiple parameter models under conjugacy; hierarchical models; noninformative and informative prior distributions; modern computational techniques, including Markov chain Monte Carlo; model checking; posterior predictive checks; sensitivity analysis.

416. Applied Statistics  
Prerequisite: STT 211 or STT 212 or BST 463 or equivalent.

One- and two-way analysis of variance; simple and multiple regression; analysis of covariance; analysis of residuals, use of transformations; topics from contingency table analysis and nonparametric statistics. Emphasis on real examples from the biomedical and social sciences, with extensive use of statistical software.

421. Sampling Theory  
Prerequisite: STT 203 or STT 213.

Sampling designs; theories of inference in finite populations; sampling with varying probabilities; stratified, systematic, multistage and multiphase sampling; estimation based on ratio and regression methods.

422. Design of Experiments  
Prerequisite: BST 416 or BST 464 or BST 476.  
Credit—two hours

Basic designs and their principles; randomization; blocking; use of concomitant information.

426. Linear Models  
Prerequisites: STT 203 and MTH 235.

Theory of least-squares; point estimation in the general linear model; projection operators, estimable functions and generalized inverses; tests of general linear hypotheses; power; confidence intervals and ellipsoids; simultaneous inference; linear and polynomial regression; analysis of variance and analysis of covariance models; fixed, random, and mixed effects; correlation; prediction.

441. Applied Multivariate Analysis  
Prerequisite: BST 426 or BST 476.  
Credit—two hours

Methodology and applications of multivariate analysis; Hotelling's T²; multivariate regression and analysis of variance; classification and discrimination; principal components, clustering, and multidimensional scaling; use of statistical software.

450. Data Analysis  
Prerequisites: BST 426 and BST 477 or BST 478.

Statistical analysis of data under nonstandard conditions; examination of adequacy of model assumptions; goodness-of-fit testing; transformations; robust inference.

451. Exploratory Data Analysis  
Prerequisites: BST 416 or BST 476 and BST 478.

Graphical techniques to reveal structure in data; model fitting to describe structure; model checking; transformations; outliers and resistant fitting methods.

452. Design of Experiments  
Prerequisites: BST 426 and BST 477 or BST 478.

Completely randomized designs; replication; covariate adjustment; randomized block designs; fixed vs. random effects; Latin and Graeco-Latin squares; confounding; nesting; factorial and fractional factorial designs; split-plot designs; incomplete block designs; response surfaces.

463. Introduction to Biostatistics

Introduction to statistical techniques with emphasis on applications in the health sciences. Summarizing and displaying data; introduction to probability; Bayes' theorem and its application in diagnostic testing; binomial, Poisson, and normal distributions; sampling distributions; estimation, confidence intervals, and hypothesis testing involving means and proportions; simple correlation and regression; contingency tables; use of statistical software.

464. Applied Linear Regression  
Prerequisite: BST 463 or equivalent.

One-way and two-way analysis of variance; multiple comparisons involving means; fixed and random effects; simple and multiple linear regression; analysis of covariance; interactions; correlation and partial correlation; multicollinearity; model selection; model checking.

465. Clinical Trials  
Prerequisite: BST 463 or equivalent.

Introduction to the principles of clinical trials; clinical trial protocols; overview of the drug development process; hypotheses/objectives; specification of response variables; defining the study population; randomization; blinding; ethical issues; factorial designs; crossover designs; equivalence trials; trial monitoring and interim analyses; sample size and power; issues in data analysis and reporting; evaluating clinical trial reports.

466. Categorical Data Analysis  
Prerequisite: BST 464 or equivalent.

Measures of association for categorical outcomes; contingency table analysis; regression analysis for binary, polynoumous, count and time-to-event responses; emphasis on general ideas and applications of models and methods using statistical software such as SAS; review of necessary theory underlying likelihood and nonparametric inference as it pertains to the development of relevant models and test statistics.
476. Introduction to Linear Models  
Prerequisite: STT 203 or STT 212 or BST 463.
Simple and multiple regression models; least-squares estimation; hypothesis testing; interval estimation; prediction; matrix formulation of the general linear model; polynomial regression; analysis of variance; analysis of covariance; methods for simultaneous inference; residual analysis and checks of model adequacy.

477. Introduction to Statistical Software I  
Prerequisite: STT 212 or BST 463.  
Credit—none (Computing Rotation)
Introduction to a statistical software package. The software to be introduced may vary from semester to semester; a common choice is SAS. Generally offered during the first six weeks of the summer.

478. Introduction to Statistical Software II  
Prerequisite: STT 212 or BST 463.  
Credit—none (Computing Rotation)
Introduction to a statistical software package. The software to be introduced may vary from semester to semester; a common choice is R. Generally offered during the first six weeks of the summer.

479. Generalized Linear Models  
Prerequisites: BST 411 and 426. Generalized linear models; computational techniques for model fitting; logistic and conditional logistic regression; loglinear models; models for nominal and ordinal categorical data; quasi-likelihood functions; model checking; introduction to semiparametric generalized linear models.

491. Reading Course at the Master’s Level  
Credit—varies

493. Internship/Applied Project  
Credit—eight hours
As required for completion of the MS degree in medical statistics, the student works on a medical research project under the guidance of department faculty or under supervision in an industrial setting. The student should have contact with medical investigators as well as statisticians. The work should be coherently summarized in a written document. Oral presentation of the work is required.

495. Research at the Master’s Level  
Credit—varies

497. Seminar in Statistical Literature  
Credit—one hour
Provides an introduction to the process of searching the statistical literature; opportunities to acquire knowledge of a focused area of statistical research; experience in organizing, preparing, and delivering oral presentations; and an introduction to the research interests of members of the faculty.

511. Topics in Statistical Inference I  
Prerequisite: BST 412 or BST 413.
Advanced topics in statistical inference and/or decision theory.

512. Topics in Statistical Inference II  
Prerequisite: BST 412 or BST 413.
Advanced topics in statistical inference and/or decision theory.

513. Analysis of Longitudinal and Dependent Data  
Prerequisites: BST 401 and BST 411 and BST 426.
Modern approaches to the analysis of longitudinal and dependent data; random and mixed effects models; marginal models; generalized estimating equations; models for continuous and discrete outcomes.

514. Survival Analysis  
Prerequisites: BST 411 and BST 412 or BST 402.
Parametric, nonparametric, and semiparametric methods for the analysis of survival data. Right censoring; Kaplan-Meier curves; log-rank and weighted log-rank tests; survival distributions; accelerated life and proportional hazards regression models; time-dependent covariates; partial likelihood; models for competing risks and multiple events.

520. Current Topics in Bioinformatics  
Prerequisites: BST 411 and 464 or equivalent.
Basic concepts of modern molecular biology; bioinformatics technologies; sequence analysis of nucleic acids and proteins (methods of sequence alignment and associated search algorithms); prediction of structure and functions; protein folding and RNA secondary structure; statistical methods for microarray gene expression data analysis: (1) univariate methods for selecting differentially expressed genes (SAM, step-down and step-up resampling methods, empirical Bayes method) and (2) multivariate methods for identifying subsets of differentially expressed genes and pathway recognition (distance-based and error-based approaches, successive selection of subsets of genes, testing significance in multivariate settings); selection bias in multivariate analysis and cross-validation of classification rules; Support Vector Machines in the analysis of microarrays; unsupervised learning with microarray data; identification of gene regulatory networks from gene perturbation experiments; prognostic value of molecular signatures of cancer cells; common pitfalls in gene expression data analysis and a critical overview of the existing methods; methods for analysis of complex genetic traits and gene finding in genetic epidemiology; promising avenues for future statistical research in the field of bioinformatics.
531. Nonparametric Inference  
**Prerequisite: BST 411.**

Statistical procedures based on ranks, order statistics, signs, permutations, and runs; tests for randomness, symmetry, and independence; invariance considerations and optimality; treatment of ties; distributional problems and asymptotic theory; U-statistics; Chernoff-Savage theorem; robustness and efficiency.

536. Sequential Analysis  
**Prerequisite: BST 412.**

The Wald sequential probability ratio test and generalizations; tests of composite hypotheses; nonparametric sequential procedures; sequential estimation and confidence intervals; Brownian-motion based sequential methods, with applications to clinical trials; group sequential methods; optimal stopping rules.

541. Multivariate Analysis  
**Prerequisites: BST 411 and BST 426.**

Multivariate normal and Wishart distributions and associated distributions; estimation; invariance reduction; Hotelling’s $T^2$; multivariate general linear model; simultaneous confidence bounds; step down procedures; optimality properties; classification; discrimination; principal components.

550. Topics in Data Analysis  
**Prerequisite: Permission of instructor.**

Advanced statistical methods for data analysis.

570. Topics in Biostatistics  
**Prerequisite: Permission of instructor.**

Advanced biostatistical techniques.

582. Introduction to Statistical Consulting  
**Prerequisite: Permission of instructor.**

Formal instruction on developing and managing consulting relationships.

590. Supervised Teaching  
**Credit—varies**

One to two classroom hours per week of discussion and problem solving with University of Rochester students, under the guidance of a member of the faculty.

591. Reading Course at the PhD Level  
**Credit—varies**

Special work for doctoral candidates, arranged individually.

592. Supervised Statistical Consulting  
**Credit—varies**

Supervised consulting with medical and other scientific researchers under the guidance of a member of the faculty.

595. Research at the PhD Level  
**Credit—varies**

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**Comparative Medicine**

Professor Wyatt  
Associate Professor Moorman-White  
Assistant Professor Bates  
Residents Keene, Gordon

Graduate instruction is offered by the faculty of the Department of Comparative Medicine in areas related to the use of animals in medical research and teaching programs. Residency training in laboratory animal medicine is offered as a two-plus year program for veterinarians preparing for careers in this specialty.

395. Independent Study  
**Prerequisites: two years of undergraduate study or a graduate degree in biological sciences.  
Credit—one to four hours**

An independent study course involving a research project mentored by a department faculty member.

402. An Introduction to Laboratory Animal Biomethodology  
**Prerequisite: B.S. in biological sciences or professional degree (MD, DDS, or DVM) or permission of instructor.  
Credit—one hour**

The selection of the appropriate animal model, the principles of animal care and research techniques using animals is presented. Through the use of lectures, readings, and laboratories, the principles necessary to properly and humanely use laboratory animals are taught. This course is recommended for young scientists who will be using laboratory animals as models for the investigation of biological phenomena or as surrogates for man in their professional careers. (Spring)
Dentistry

Professors Bahreman, Berkowitz, Billings, *Caton, Elad, *Fishman, *Graser, Malmström, Meyerowitz (Chair), Saunders, *Subtelny, Tallents, Quivey, Westesson


Assistant Professors Abayon, Carlson, *DeRosa, Fantuzzo, Gajendra, McLaren, Meirelles, Shastri, Tasgaonkar, *Yunker

The Eastman Department of Dentistry offers graduate dental residency programs in postdoctoral general dentistry (advanced education in general dentistry and general practice residency), oral and maxillofacial surgery, orthodontics, pediatric dentistry, periodontics, and prosthodontics. In addition, the department cooperates with other departments in the School of Medicine and Dentistry in offering programs leading to an MS or PhD degree in one of the basic medical sciences or an MS degree with a major in dental sciences as described under the Center for Oral Biology. Both the MS and PhD programs are open only to postdoctoral students who already hold a DDS, DMD, or equivalent degree. These programs are integrated with advanced clinical training programs and are designed for those planning a career in teaching and research in dentistry. In addition, selected residents in oral and maxillofacial surgery pursue an MD degree linked to their residency training.

Genetics

Professors 5Bambara, 3Berk, 3Bohmann, 4Chen, 3Dewhurst, 3Dumont, 3Eickbush, 11Freeman, 3Gan, 3Goldfarb, 3Hayes, 3Jordan, 3Kim, 3Land, 3Maquat, 3Noble, 3O’Keefe, 3O’Reilly, 3Palis, 3Perkins, 3Phizicky, 3Schwarz, 3Sherman, 3Smith, 3Thornton, 3Werren

Associate Professors 10Ackerman, 5Bi, 3Blaxall, 2Bulger, 5Butler, 3Fry, 3Giger, 3Grayhack, 4Hilton, 3Hsu, 5Jasper, 5Maggirwar, 3Mariani, 3Mayer-Pröschel, 3Nehrke, 3Pearce, 3Portman, 3Robert, 3Welte, 3Zhao

Assistant Professors 3Becker, 5Fowell, 4Kiernan, 4Korshunov, 3Libby, 3Maggirwar, 5McMurray, 5Ovitt, 3Pröschel, 3Que, 3Rempe, 3Samuelson, 3Xu

The graduate program in genetics offers doctoral training in the general areas of molecular and cellular biology with emphasis on biomedicine, genomics, and animal development. This is a very dynamic field with creative, multidisciplinary research addressed to problems of medical and biological relevance. The program of genetics combines faculty from multiple basic science and medical departments to provide a well-rounded training for a successful career in this area.

Training in the first year of the program comprises introductory graduate-level classes in molecular biology, biochemistry, and cell biology. These classes lay the foundation for advanced courses on specialized topics such as animal developmental genetics and various electives such as signal transduction or microbial genetics.

The genetics program emphasizes practical work in the research laboratory. Three laboratory rotations are a major component of the first year. During these rotations graduate students perform research projects in the laboratory of a faculty member affiliated with the program. The purpose of the rotation is to give the student experience in conducting independent research and to provide them with an in-depth view of the scope of research pursued by the program faculty. Typically, but not necessarily, graduate students choose one of the labs that have hosted the rotations for their PhD research.

Training in the second and the following years includes in-depth specialized elective courses and participation and presentation in departmental and laboratory seminar series, as well as journal clubs. Students are also expected to assist in the teaching of at least one course. In addition, students receive education on issues of science ethics. An external seminar series with high-caliber, invited speakers in the areas of genetics, genomics, development, and cancer biology provides students with the opportunity to gain up-to-date insight into cutting-edge science in their field and to interact with experts in their field of study.

1Department of Biochemistry and Biophysics, 2Department of Biology, 3Department of Biomedical Genetics, 4Department of Medicine, 5Department of Microbiology and Immunology, 6Department of Neurobiology and Anatomy, 7Department of Neurology, 8Department of Orthopaedics, 9Department of Pathology and Laboratory Medicine, 10Department of Pediatrics, 11Department of Pharmacology and Physiology, 12Department of Ophthalmology.

* Part-time
In addition, there is a wide and vibrant spectrum of relevant internal and external seminars throughout the School of Medicine and the basic science departments of the College.

Graduate student research projects are supported and monitored by the respective mentor and a graduate committee that consists of four faculty members. Typically after the second year of the program, students have to pass a midterm examination that qualifies the candidate for pursuing a PhD in genetics.

REQUIRED COURSES

IND 408. Biochemistry
Prerequisite: a one-semester introductory course in biochemistry or equivalent.
Credit—five hours
This course is designed primarily for graduate students. Eighty-minute lectures cover selected topics in modern biochemistry, including analysis of protein and domain structure by classical and modern methods, including mass spectrometry, NMR, X-ray crystallography, and other biophysical techniques; protein-ligand and protein-protein interactions; enzyme kinetics and catalytic mechanisms; and, cellular energy production and utilization. In addition to lectures, workshops are held once a week, during which time selected papers from the literature are discussed. (Fall)

IND 409. Cell Biology
This course is intended primarily for first-year graduate students with some previous coursework in cell biology. One-hour lectures include discussion of specific modern topics including cell cycle and its breakdown during cancer and apoptosis; cytoskeleton; intracellular compartments and protein sorting; signal transduction and cell-cell communication; membrane structure and transport. In addition to the lectures, weekly interactive journal-club-style sessions explore the current cell biology literature. (Fall)

IND 410. Molecular Biology and Genetics
This course is designed primarily for graduate students. One-hour lectures cover modern topics of interest, including cell cycle and its breakdown during cancer and apoptosis; cytoskeleton; intracellular compartments and protein sorting; signal transduction and cell-cell communication; membrane structure and transport. In addition to the lectures, weekly interactive journal-club-style sessions explore the current cell biology literature. (Fall)

IND 501. Ethics in Research
Credit—none
This course is offered online and is required of all first-year graduate students and new postdoctoral fellows in the School of Medicine and Dentistry. The course features seven modules that provide information about the various topics that the National Institutes for Health consider essential to understanding the responsible conduct of research. (Fall)

GEN 503/504. Genetics Seminar
Credit—one hour
Seminar courses are given each semester, and continuous registration is required of all students in genetics. The genetics seminar is a forum for presentation of current research in genetics. Students in the genetics program are required to present their research in the seminar every 12–16 months starting at the end of year two. Seminars are held weekly.

GEN 507. Advanced Genetics and Genomics
This course offers in-depth discussions of theoretical concepts and experimental strategies in genetics and genomics. Lectures cover genetically tractable model organisms, including yeast, Drosophila, Caenorhabditis elegans (a nematode), mouse, and human and their analyses from gene to genome and systems level. Examples of the particular questions that can be addressed with advantage in each genetic model are presented, and the special genetic approaches feasible in these respective systems are emphasized. The course builds upon a strong background in Mendelian and molecular genetics. Topics include the genetic basis of pattern formation, cell-fate determination, control of cell function, structure-function relationships in macromolecules, and searching for genes important in human health. Topics incorporated recently include genome structure and evolution, small RNAs and mobile genetic elements, epigenetics and genomics, proteomics, and other studies at the whole genome level. (Fall)

GEN 595. PhD Research
PhD research may be undertaken in any of the participating departments under the direction of a faculty advisor.

SUGGESTED ELECTIVE COURSES

BCH 412. Advanced Topics in Biological Macromolecules
An advanced biochemistry lecture course intended for senior undergraduate and graduate students. Topics include DNA structure, RNA structure and catalysis, nucleic acid-protein interactions, X-ray crystallography, NMR spectroscopy, protein folding, molecular chaperones, membrane proteins, posttranslational modifications of proteins, ATPases, G protein and function, protein-protein interactions, proteases, and clotting.

BIO 426. Developmental Biology
This course deals with the cellular and molecular aspects of animal development, with emphasis on processes and underlying mechanisms. Topics include embryonic cleavage, gastrulation, early development of model vertebrates and invertebrates, patterning of cell fates along embryonic axes of Drosophila and vertebrates, organogenesis, and stem cells.

GEN 506. Principles in Stem Cell Biology
This course is designed to cover basic principles in stem cell science, the role of stem cell dysfunction in developmental disease, potential therapeutic applications of stem cells, principles of embryonic stem cell and iPSC research and managing the transition
from the laboratory to the clinic. The course is structured by combining lectures and group discussions. Discussions are on research papers chosen by the lecturer to complement the material in the lecture, and discussion of these papers follows the formal lecture. Students are also required to submit a research proposal. The proposal may be on any topic in stem cell biology and undergoes three submissions, after which students receive one-on-one feedback from the instructors. (Alternate years.)

**GEN 508. Genomics and Systems Biology**
This is a graduate-level course aimed at providing students with the up-to-date scientific information and background knowledge behind the biomedical research into the molecular mechanisms of developmental processes and of disease pathogenesis. The lectures are in modular format with student reading/presentations in each module. Six modules are currently included, each by an instructor(s) most familiar with the topics. The modules include genomic and proteomic approaches to developmental/disease pathways; hematopoiesis and stem cell diseases; CNS development and systems biology; cardiovascular development and diseases; chromatin and gene regulation; and cancer genomics and biology. This course is open to all graduate students in biology and biomedical sciences and is highly recommended for the students in the Genetics, Genomics, and Development program. (Alternate years)

**IND 443. Eukaryotic Gene Regulation**
This advanced course examines mechanisms of transcription initiation, eukaryotic chromosome structure and its modifications, mechanisms of chromatin-mediated regulation of gene expression, as well as epigenetics and functional genomics. Lectures and readings draw heavily on primary literature both classic and most recent. IND 443 and BIO 443 students are required to give a 30-minute presentation on a selected topic.

**IND 447. Signal Transduction**
Cellular signal transduction is a widely studied topic in the biomedical sciences. Cells have multiple-signal transduction mechanisms for sensing their chemical environment and converting the external signals into coordinated physiological responses. The course covers a spectrum of topics, including basic principles and mechanisms in cell signaling, contemporary experimental approaches to understanding signaling processes, and the role of signal transduction in normal and pathophysiology.

**MBI 421. Microbial Genetics**
An in-depth examination of some representative genetic systems in bacteria and viral viruses. Topics include mutations and mutagenesis, recombination and repair, mechanisms of genetic exchange, transposable elements, and the control of gene expression. (Alternate years)

**MBI 473. Immunology**
Innate and adaptive immunity; structure and genetics of immunoglobulins and T cell receptors; lymphocyte development, immune regulation, immunological diseases, tumor immunity.

### Interdepartmental Courses

**408. Biochemistry**
*Prerequisite: a one-semester introductory course in biochemistry or equivalent.*
*Credit—five hours*
This course is designed for graduate and advanced undergraduate students. Eighty-minute lectures cover topics at the forefront of current biochemistry and biomedical research, including analysis of protein and nucleic acid structure by NMR, X-ray crystallography, and other biophysical and computational approaches, single-molecule techniques, proteomics, protein folding, protein-lig and protein-protein interactions, enzyme kinetics and catalytic mechanisms, membrane proteins, glycoproteins, and cellular energy production. In addition to lectures, workshops are held once a week, during which time selected papers from the current literature are discussed. (Fall)

**409. Cell Biology**
*Credit—four hours*
This course is designed for graduate and advanced undergraduate students. Eighty-minute lectures cover topics at the forefront of current biochemistry and biomedical research, including analysis of protein and nucleic acid structure by NMR, X-ray crystallography, and other biophysical and computational approaches, single-molecule techniques, proteomics, protein folding, protein-lig and protein-protein interactions, enzyme kinetics and catalytic mechanisms, membrane proteins, glycoproteins, and cellular energy production. In addition to lectures, workshops are held once a week, during which time selected papers from the current literature are discussed. (Fall)

**410. Molecular Biology and Genetics**
*Credit—four hours*
This course is designed primarily for graduate students. One-hour lectures cover modern topics of interest, including DNA replication; DNA repair and mutagenesis; regulation of eukaryotic RNA transcription, RNA processing, and protein translation. Emphasis is placed on both biochemical and genetic approaches to the study of these problems. Special additional topics include genomics as an approach to regulation and mammalian genetic techniques of analysis. (Spring)
411. Methods in Structural Biology  
Prerequisites: calculus; physics or permission of course coordinator.  
Credit—five hours  
A practical introduction to the theory and application of the major techniques used in the determination of atomic resolution structures of biological macromolecules. These include X-ray crystallography, NMR spectroscopy, and computational and modeling methods. The goal is to allow nonspecialists from any discipline to critically read the relevant literature and understand the limitations of these techniques. (Spring, alternate years)

412. Graduate Experience in Science Education  
Credit—three hours  
This course introduces graduate students interested in pursuing academic career tracks to some fundamental understandings behind the theories, principals, and concepts of science education. Students learn practical teaching and communication skills to help them relate science content to and increase their confidence in their teaching abilities. The knowledge and skills in lesson and course design, classroom instructional strategies, and differentiated assessment practices are useful to graduate students as they continue in their growth as educators throughout their careers.

443. Eukaryotic Gene Regulation  
Prerequisites: introductory courses in genetics, biochemistry, and molecular biology are strongly recommended.  
This course systematically examines the organization of the eukaryotic genome and its role in the regulation of gene expression. Topics discussed include structure of chromosomes, mechanisms of gene activation and transcription, epigenetic gene regulation, regulatory networks, and functional genomics. Lectures and readings draw heavily on current and classic primary literature.

447. Signal Transduction  
Cellular signal transduction is one of the most widely studied topics in the biomedical sciences. It has become clear that cells have multiple mechanisms for sensing the environment and converting the external signals into intracellular responses. The goal of this course is for students to learn modern concepts in signal transduction. The lectures cover a spectrum of topics ranging from basic principles and mechanisms of signal transduction to contemporary techniques for doing research in this area. (Spring)

501. Ethics and Professional Integrity in Research  
Credit—one hour  
This course is required of all graduate students in the biomedical sciences and clinical disciplines in the School of Medicine and Dentistry. The course features eight modules that provide information about the various topics that the National Institutes for Health consider essential to understanding the responsible conduct of research, including human experimentation/conflict of interest, animal experimentation, stem cell research, mentor-student relationship, plagiarism/scientific misconduct, publication/copyright. The course is offered in a lecture/case study and small discussion group format. (Fall)

502. Ethical Issues in Human and Animal Research  
Credit—two hours  
The objective of this course is to explore the ethical and philosophical foundations regarding the involvement of human and animal subjects in research. Ethical theories, laws, and national regulations that have been developed prompt discussion of contemporary ethical problems and proposed solutions. This seminar course is designed for small group discussion with individual exploration of current ethical issues in the research enterprise. (Spring)

506. Ethics and Professional Integrity in Research—Postdoctoral  
Credit—none  
This course is required of all postdoctoral appointees in the basic science and clinical disciplines in the School of Medicine and Dentistry who are supported by federal training grants. The course features eight modules that provide information about the various topics that the National Institutes for Health consider essential to understanding the responsible conduct of research including human experimentation/conflict of interest, animal experimentation, stem cell research, mentor-student relationship, plagiarism/scientific misconduct, and publication/copyright. The course is offered in a lecture and small discussion group format. (Fall)

507. Advanced Genetics  
Prerequisite: introductory course in genetics.  
This course constitutes in-depth discussions of several genetic model systems, including yeast, Drosophila, Caenorhabditis elegans (a nematode), Arabidopsis, zebrafish, and mouse. Studies of the particular questions that can be addressed with advantage in each genetic model and the special genetic approaches feasible in these respective systems are emphasized. The course builds upon a strong prior background in Mendelian and molecular genetics. Topics covered include genetic basis of pattern formation, cell fate determination, control of cell function, structure-function relationships in macromolecules, and searching for genes important in human health. The yeast paradigm emphasizes the utility of a simple, eukaryotic microorganism in addressing fundamental biological questions by genetics. Studies of Drosophila, nematode, Arabidopsis, and zebrafish genetics illuminate the general principles behind the control of pattern formation and the cell fate specification in complex organisms across wide evolutionary scales. The zebrafish and mouse models illustrate two alternative approaches to vertebrate genetics. (Spring)

520. New Frontiers in Mitochondrial Medicine  
Credit—two hours  
A seminar/reading course on current topics in mitochondrial research. The objective is to gain experience discussing and critically evaluating primary research articles that focus on mitochondrial biology in topics related to human developmental biology and aging, mammalian evolution and genetics; nuclear: mitochondria trafficking, mtDNA disease pathogenesis, oxidative phosphorylation and oxidative stress, or degenerative
disorders. The course is guided by an instructor who meets with the students on a weekly basis to assist in the selection of relevant readings and to discuss key issues. This elective course is designed for graduate students who have an interest in mitochondrial biology but it (and presentations) is open to graduate students, upper-division undergraduate students, medical students, residents, staff, and interested members of the faculty. (Fall)

Marriage and Family Therapy

Professor McDaniel
Associate Professors Gawinski, le Roux, Podgorski (Co-Director), Speice (Co-Director), Watson
Assistant Professors Pisani, Rosenberg
Senior Instructor Swanger-Gagné
Clinical Associate Professors Driscoll, Seaburn
Clinical Assistant Professors Chiang, Yeager
Clinical Senior Instructors Briody, Guiffre

The Department of Psychiatry offers a Master of Science degree and Post-degree Certificate in marriage and family therapy through the Family Therapy Training Program, Institute for the Family.

The Family Therapy Training Program has a long history of providing family therapy training and continuing education locally, nationally, and internationally. Built on the work of faculty pioneers in the areas of serious mental illness, substance abuse, and cultural transition, postgraduate training has been provided since 1983. The program trains professionals from multiple disciplines, including medicine, nursing, social work, psychology, clergy, and education.

Coursework provides a broad-based, integrative, biopsychosocial approach to clinical practice. The program is committed to a systems and relational understanding of human functioning. The goals of the MS in marriage and family therapy are to (1) provide comprehensive training in marriage and family therapy skills; (2) teach the major systems approaches and theories and how these theories relate to psychopathology and are integrated across the life span, gender, sexuality, race, and culture; (3) prepare culturally aware marriage and family therapists; and (4) train students who are well versed in a scientist practitioner model. The program combines rigorous coursework with intensive clinical training.

Courses in the program blend conceptual, clinical, and self-of-the-therapist considerations to prepare family therapists for professional practice. Clinical training is provided in a variety of supervised formats and settings: Family Therapy Services (Strong Behavioral Health), a community hospital, primary care health center, program for the seriously and persistently mentally ill, and community mental health centers.

Applicants typically have a bachelor’s degree in education, psychology, social work, sociology, or nursing. In order to graduate, students must successfully complete 60 credit hours that include a supervised clinical practicum.

The Marriage and Family Therapy Training Program at the University of Rochester is accredited by the Commission on Accreditation for Marriage and Family Therapy Education (COAMFTE) of the American Association for Marriage and Family Therapy (AAMFT).
THEORETICAL FOUNDATIONS

**PSI 539. Family Therapy Theory and Technique**
This course provides an overview of the family therapy field and focuses on the major therapeutic approaches including current trends in family therapy practice.

**PSI 560. Narrative and Integrative Approaches to Family Therapy**
This course focuses on the use of language, storytelling, metaphor, and the construction of meaning in family therapy and in the life of the therapist. Students review cutting-edge literature from multiple disciplines interested in how language and storytelling shape peoples’ lives.

CLINICAL PRACTICE

**PSI 492. Medical Family Therapy Intensive**
This course blends didactic and experiential methods to teach students how to work with families dealing with illness and how to collaborate with physicians and other health care professionals.

**PSI 541. Foundations of Clinical Practice in Family Therapy**
In this course, students are taught interviewing and documentation skills, have exposure to families in nonclinical settings, learn the biopsychosocial model, and explore person-of-the-therapist issues.

**PSI 542/562. Clinical Assessment in Family Therapy/Family Therapy Practice**
These courses prepare students specifically for Clinical Practicum and provide extensive training in comprehensive clinical assessment and therapeutic interventions.

**PSI 543. Psychopathology and Systems**
Students learn traditional diagnostics and psychopathology within a systems framework. The course enables students to approach families from a biopsychosocial systems assessment paradigm.

**PSI 566. Couples Therapy**
Couples therapy teaches students couples therapy theory and technique using readings in the field and examination of videotape and other material.

**PSI 574. Child-focused Family Therapy**
This course includes child-development issues, working with children, and working with family cases that have a child focus.

**PSI 587/588. Clinical Practicum**
All students are required to complete a supervised clinical practicum at approved clinical sites.

INDIVIDUAL DEVELOPMENT AND FAMILY RELATIONS

**PSI 545. Human Development Across the Family Life Cycle**
This course teaches family of origin theory and its role in clinical practice. Students have the opportunity to present their own genograms as well as read the literature on transgenerational issues in family therapy.

**PSI 570. Gender, Human Sexuality, and Culture**
Students learn the role that gender, race, ethnicity, sexual preference, and cultural beliefs play in family life and clinical practice.

PROFESSIONAL IDENTITY AND ETHICS

**PSI 548. Family Therapy Ethics and Professional Practice**
In Ethics students will learn the AAMFT Ethical Code expectations dealing with such issues as confidentiality, dual relationships, individual and family welfare, etc. Students also address personal issues related to the impact of values, beliefs, race, and ethnicity on the practice of family therapy.

**PSI 564. Family Law, Policy, and Social Services**
This course prepares marriage and family therapists (and other mental health practitioners) to integrate pertinent legal information, specifically related to divorce and custody and partner violence into their clinical practices. The course content focuses on the legal contexts and procedures relevant to the intersection of MFT/MH practice and the law. Legal issues related to documentation are reviewed.

RESEARCH

**PSI 572. Family Therapy Research**
In Family Therapy Research students are introduced to quantitative and qualitative methods in family therapy research and learn to critically examine and utilize research findings in clinical practice.

**PSI 584. Master’s Project**
All master’s degree students complete a master’s project that is designed by the student in conjunction with his or her advisor and the director. The focus of the project is clinical, reflecting the student’s cumulative theoretical and clinical learning.
Microbiology and Immunology

Assistant Professors Elliott, Lemos, Martinez-Sobrido, *Munger
Research Associate Professors *Bottaro, Jin, Livingstone, Quahter, Sangster
Research Assistant Professors Abranches, Gerber, Mattiacio, Polesskaya, Stone, Xu
Scientist Holtfreter
Professors Emeriti Abraham, Allen, Bowen, Christensen, Clark, Cohen, W. Iglewski, Manillof, Marquis, Silver

Applicants for admission to graduate study in the Department of Microbiology and Immunology should have an undergraduate major in biological or physical sciences. The usual minimal requirements are general biology, general chemistry, analytical chemistry, and organic chemistry. Applicants seeking the PhD degree are expected, in addition, to have a year of mathematics and physics. Physical chemistry and biochemistry are desirable. The major goal of the graduate program in microbiology and immunology is to prepare students, through a PhD training program, for a scientific career in one of the several areas included in the broad categories of microbiology and immunology. All programs will involve a basic grounding in biochemistry, and will include an important emphasis in biology at the molecular and cellular levels. The department offers several tracks leading to a PhD in microbiology and immunology. Particulars about the PhD programs in the various tracks are available from the departmental office on request.

The MS degree (Plan A) is intended for those whose career goals are in research. The course program includes microbiology, biochemistry, and additional courses appropriate to the individual's area of research plus thesis research. The thesis, while not expected to be as extensive as a PhD thesis, must be based on research of significant scientific value. In most cases the candidate must spend approximately two years to complete the program.

Persons who wish to increase their training in microbiology and immunology, but whose career goals are other than research, may earn the MS through Plan B. These career goals might include technical employment or nonuniversity teaching. The program consists of approximately 30 hours of coursework, selected for the most part from courses satisfying the core requirement for the PhD. In addition, a written essay consisting of a critical review of some area of microbiological literature plus a final oral examination based on the essay and on the relevant material covered in courses are required.

* Primary appointment in another department

401. Biology of HIV/AIDS
Credit—one hour
This course provides an in-depth exposure to key issues in HIV/AIDS research including molecular biology and the lifecycle of the virus, transmission and pathogenesis, immune responses, antivirals, microbicides and vaccines, reservoirs, and attempts to cure HIV infection.

402. Writing in Microbiology
This course provides a hands-on introduction to scientific writing geared towards biologists. The curriculum encompasses a wide range of writing applications including peer-reviewed scientific manuscripts, scientific reviews, grant proposals, and scientific articles for general audiences. Sections on how to organize data for proposals and publication are included; there is also a section on scientific presentations and PowerPoint. This course can satisfy the upper-level writing requirement.

403. Drug Discovery
Credit—two hours
This course is designed to provide graduate-level and senior undergraduate students with an introduction to current Drug Discovery processes, with special emphasis placed on antimicrobial development. The course is taught by University of Rochester faculty with drug discovery research programs as well as internationally recognized leaders in requisite fields of pharmaceutical practices from biotechnology and pharmaceutical industry. Topics covered include, but are not limited to, bioinformatics-based drug target identification, high throughput screening approaches (and pitfalls), medicinal chemistry, hit to lead optimization, clinical trial design, and intellectual property and portfolio management.

404. Introduction to Emerging Pathogens
Credit—three hours
The past several decades have been marked by the emergence of exotic pathogenic microorganisms and their introduction into the human population. This course documents the history of the appearance and spread of these emergent pathogens, and discusses mechanisms that govern the selection of new pathogenic strains and species, with a particular focus on the evolution of zoonotic infectious agents and their adaptation to new hosts. The role of deforestation, globalization, and climate change in the development of emergent pathogens is also considered, as well as the potential risks posed from future technological advancements, such as synthetic biology and bioterrorism.

414. Mechanisms of Microbial Pathogenesis
Prerequisites: MBI 220 and 221.
Credit—four hours undergraduate, three hours graduate
An examination of host-parasite interactions and the mechanisms by which microbes evade the host response and cause disease. The emphasis is on an understanding at the molecular level of microbial pathogenesis, including colonization, invasion, antigen variation, toxin production, pathogen recognition, and host defense responses including innate immunity and inflammation.
Graduate students must register for MBI 514 seminar. (Spring, alternate years)

421. Microbial Genetics
Prerequisite: MBI 220.
Credit—four hours undergraduate, three hours graduate
This course provides an in-depth examination of representative genetic systems in bacteria and bacterial viruses. Emphasis is placed on the methods of genetic analysis used to study biological function. The material covered includes the nature of bacterial variation, processes affecting gene synthesis and integrity, the nature of gene transfer in bacteria, and the regulation of gene expression in prokaryotes. (Spring, alternate years)

431. Microbiology Physiology
Prerequisite: a course in biochemistry.
Credit—four hours undergraduate, three hours graduate
This course provides a survey of microbial physiology with emphasis on metabolism, regulation, cell walls, membranes, ecology, and adaptation to extreme environments. The class meets twice per week for two lectures of 75 minutes each. Extensive handout materials are provided, and readings are from the current literature. PhD students must register for MBI 531 seminar. (Fall, alternate years)

456. General Virology
Credit—five hours undergraduate, four hours graduate
Provides an introduction to virology. Topics covered are general methodology of virus research, virus structure, biochemistry of viral replication, and general features of virus-host cell interaction. (Fall)

473. Immunology
Prerequisites: BIO 121; BIO 150 or equivalent. BIO 202 strongly recommended.
Credit—four hours undergraduate, three hours graduate
Innate and adaptive immunity; structure and genetics of immunoglobulins and T cell receptors; lymphocyte development, immune regulation, immunological diseases, tumor immunity. (Fall)

491. Reading Course at the Master’s Level
Credit to be arranged

493. Master’s Essay
Credit to be arranged

495. Master’s Research
Credit to be arranged

501. Microbiology and Immunology Student Seminar Series
Credit—one hour
A program of seminars held once a week and conducted by graduate students is presented each semester. Continuous registration is required of all PhD students in the Department of Microbiology and Immunology; attendance of departmental faculty is also expected. The objective is to train students to present their research in a form accessible for a non-specialized scientific audience. Student starting from their second year are required to present three times. The presentations of the second-and third-year students should last 20 minutes, followed by 10 minutes for questions. It should include background information, rationale, experimental design, and relevance of the project; preliminary data are welcome but not essential. The presentations of fourth-year students should be a formal, 45-minute long “research in progress” seminar allowing 10–15 minutes for questions. Fifth-year or higher students have the opportunity to also present a 20-minute talk. Each presenter is expected to answer questions from other students and from faculty in the audience. The time devoted to questions is integral and critical for the 501 training. Confidential evaluation from faculty and students provides feedback to each presenter.

507. Graduate Microbiology Laboratory Rotations
Credit—eight hours
Consists of a series of laboratory experiences, each of approximately six weeks, in laboratories of several faculty members. Usually, PhD students are expected to enroll for three rotations.

514. Pathogenic Mechanism Seminar
Credit—one hour
Seminar offered concurrently with MBI 414. Required for PhD students. (Spring, alternate years)

515. Advanced Immunology
The Advanced Immunology course focuses on issues related to antigen-specific immunity. The course stresses the molecular aspects of antigen-specific recognition and cell-cell interactions for both the development and activation of T and B cell lineages. Key checkpoints in development and activation are emphasized as well as important regulatory mechanisms in lymphocyte activation and function. Finally, factors that control protective immune responses to pathogens and autoimmunity are discussed. All topics within the course are presented primarily within experimental frameworks and scientific literature. The topics are introduced using data from original papers in order to analyze underlying hypotheses, experimental strategies, and interpretation of experimental results. Through discussions in class, take-home problem sets, and in-class exams, the course encourages students to think critically, integrate diverse areas of knowledge, and develop an appreciation of the experimental approaches that have been used and that are currently used to move the field of immunology forward. (Spring, alternate years)

518. Critical Thinking in Research
Prerequisite: The core first-year graduate courses (Biochemistry, Cell Biology, and Molecular Biology) are required for graduate students taking this course.
Credit—one hour
Students present a history of the experimental work that provides the basis of their PhD thesis research project. The history includes a selection of published and unpublished work from their advisor’s lab and other labs in the same field that provides a rationale for
undertaking the project. Students conclude with a report of their own published and preliminary data. The focus throughout is on interpreting experimental data and engaging student interactions through questions and answers that clarify and extend material being presented. The course meets at least seven times during each semester, for 90 minutes. The course is intended for predoctoral trainees in their second year (or later) of graduate training. It is mandatory for all graduate students who are supported by institutional NIH Training Grants awarded to the department. The course is also open to students who are beginning their second year of studies and wish to be considered for appointment to these Training Grants in the future.

521. Topics in Microbial Genetics  
Credit—one hour  
This is the concurrent seminar required for graduate students registering for MBI 421. (Spring, alternate years)

531. Microbial Physiology Seminar  
Credit—one hour  
Seminar offered concurrently with MBI 431. Required for all PhD students taking MBI 431. (Fall, alternate years)

540. Advanced Topics in Immunology  
Prerequisite: permission of instructor.  
Credit—two hours  
An in-depth inquiry (via student seminars, class discussions, original literature) into one contemporary facet or subfield of immunology. Selection of the topic for a given seminar is at the discretion of the students and the immunology faculty member who is responsible for the course that semester. Previous topics include T-cell Recognition in Tumor Immunity and Autoimmunity, Behavioral Regulation of Immunity, and The Genetics of the Mouse and Its Application in Immunology. (Spring)

570. Molecular Biology Seminar  
Credit—one hour  
Seminar and journal club series required for all PhD microbiology students. This course involves the discussion of the primary literature to explore the molecular mechanisms used by various microbes to interact with their environment and to interact with the host during pathogenesis. Students are required to present papers and participate in discussion of the presented material. (Fall and Spring)

573. Immunology Seminar  
Credit—two hours  
This course coordinates with MBI 473 covering topics discussed in the lectures in greater depth with an emphasis on critical reading of original journal articles. Two to four papers are read each week with oral presentations by the students and participation in discussion of the presented material. (Fall)

580. Immunology Journal Club and Research-in-Progress Seminar  
Prerequisite: MBI 473.  
This course is the weekly one-hour Immunology Research-in-Progress seminar series. In any semester, various faculty members from immunology research laboratories at the University of Rochester offer seminar courses related to the area of their ongoing research projects. Announcement is made on the department bulletin board. (Fall and Spring)

581. Oral Microbiology  
Credit—two hours  
The bacteriology of dental caries and periodontal disease is considered in terms of current research on physiology, genetics and pathogenic mechanisms. Virology and mycology related to oral disease are reviewed, as well as sterilization and disinfection. There is no textbook for this course, but there is a handout and assigned readings from the literature for each session, which includes a lecture and a seminar based on student reviews of current research papers. (Fall, alternate years)

582–589. Specialty Seminars  
Prerequisite: permission of instructor.  
Credit to be arranged  
In any semester, various faculty members may offer seminar courses related to the area of their research interests. Announcement is made on the department bulletin board.

588. Virology Research Seminar  
Credit—one hour  
This course provides a forum for discussion of ongoing work in virology research laboratories at the University of Rochester. Topics include vaccine research, drug development and testing, gene therapy, and basic virology. (Fall and Spring)

589. Advanced Topics in Virology  
Credit—one hour  
Advanced topics in virology are investigated in a discussion course. Previous topics include anti-viral therapy, vaccine design, molecular mechanism of virus assembly, viral pathogenicity, and viral transcription regulation. Students discuss manuscripts and review articles. (Fall)

593/594. Special Topics in Microbiology  
Credit to be arranged  
Directed studies in the field of microbiology, supervised by a senior faculty member and organized to meet the needs of individuals or small groups of graduate students.

595. PhD Research  
Credit to be arranged  
Research may be undertaken in virology, general medical microbiology, animal parasitology, immunology, genetics, physiology, bacterial cytology, and cellular immunology.
Neurobiology and Anatomy


Assistant Professors *Crane, *Holt, Kornack, White

Research Associate Professors *J. Walton, *Wood

Research Assistant Professors Allen, Davidson, Rittenhouse, M. Walton

Professors Emeritus DelCerro

The Department of Neurobiology and Anatomy is recognized for its excellence in research programs and for its commitment to teaching and leadership in both graduate and medical education. Over 50 faculty (primary and joint) are actively engaged in research on the structure and function of the nervous system across several levels of inquiry. Areas of interest cover a broad spectrum, including sensory, motor and integrative systems, cell signaling and transmission, development and aging, neurobiology of disease, learning and plasticity, neuro-engineering, and computational neurobiology. Extensive state-of-the-art instrumentation and methodologies are available for investigators, students, and staff, both within labs and across a set of departmental research cores. Close interactions among departments and centers sharing interests in neuroscience ensure that this discipline holds a leading presence throughout our unified medical and college campus, while the Department of Neurobiology and Anatomy remains central to Rochester’s research and teaching programs in the neural sciences. For students as well as fellows and visiting faculty, this translates into a highly attractive environment for training and career development. This environment has recently expanded with an influx of new faculty, accompanied by a new diversity of interests and talents that has catalyzed a variety of novel educational and research opportunities and plans. Our Web site provides an evolving guide to our community and its programs (www.urmc.rochester.edu/smd/nanat).

An enduring departmental role continues to be its commitment to education. This commitment includes extensive participatory and leadership roles in medical, graduate, and undergraduate curricula at the University of Rochester. Faculty in the department have received a continuous stream of awards for teaching and leadership efforts over the years, including a fifth of all Dean’s Teaching Scholars Awards, and recurrent commendations conveyed by students.

The department plays a central role in graduate education within the neural sciences community at the University. In addition to our own Neuroscience Graduate Program, commitments include extensive instructional and leadership roles in the graduate programs of brain and cognitive sciences, biomedical engineering, and others. Interconnections between different levels of clinical education and graduate education are also strong. In addition to committed involvement in the MD/PhD program, we offer an Academic Honors Program in Medical Neurobiology (MD/MS), which adds an additional year of study, research, and teaching experience to the medical curriculum, culminating in an MS degree in neurobiology and anatomy along with the MD degree upon graduation.

The PhD program in neurobiology and anatomy is particularly well suited to students in the University’s MD/PhD program and to PhD candidates interested in the characteristics of, and mechanisms underlying, function and dysfunction of the nervous system. The program is specifically directed toward preparation for academic careers within a medical school setting, where teaching in medical and graduate school curricula comprises a strong component of faculty mission, and where research interests include systems, integrative, and translational/clinal attributes of neural science.

The Neuroscience Graduate Program provides a comprehensive, research-intensive training experience for students seeking a PhD degree in the study of the nervous system. The first-year curriculum provides students with a thorough understanding of the fundamental concepts that underlie contemporary neuroscience, from the molecular and cellular to systems level. Active learning is fostered through participation in the Neuroscience Journal Club and Student Seminar and through a series of laboratory rotations with faculty selected by the student. At the end of the first year, students choose a PhD degree track (neuroscience or neurobiology and anatomy) and thesis advisor. To those choosing the neurobiology and anatomy PhD track, a rare opportunity is offered—students choose one of the two medical school courses associated with the department, depending upon interest; Human Structure and Function includes gross anatomy, yielding an appreciation of the peripheral nervous system and its diverse interactions with numerous functions of the body, while Mind, Brain, and Behavior approaches neuroscience from a distinctly human perspective with emphasis on clinical implications and mechanisms. Additional electives are chosen to provide a more specialized emphasis as students approach their extended research training. Graduate students in neurobiology and anatomy are encouraged to exploit the multidisciplinary talents of our faculty in basic and clinical disciplines to achieve the research goals of their dissertation projects. Numerous collaborative research programs offer opportunities with colleagues in associated departments. Finally, teaching requirements and opportunities are prominent in the program, in order to instill the confidence necessary to impart knowledge to others, and to prepare students for their eventual roles as teacher/researchers of the future.

405. Hearing and Balance: Structure, Function, and Disease
Credit—three hours

This course is designed as a survey course to on auditory and vestibular structure, function, and disease with an overview perspective of select peripheral and central auditory vestibular system disorders that are prevalent in the pediatric and adult populations. Factors and issues related to diagnostic and rehabilitative strategies and outcomes also are examined. The course is
presented in a lecture format, supplemented by handouts, visual media, and Internet/Web–based links. Class discussion is a key objective in this course. (Fall)

491. MS Reading

495. MS Research

503. Neuroscience Student Seminar

Credit—one hour

The series focuses on research presentations by students in the neuroscience cluster. First-year students deliver two 20-minute talks focused on their lab rotations, and students in their second year and beyond deliver one seminar per year. At the end of each seminar, participants complete an evaluation to provide the presenter with feedback on various aspects of his or her presentation.

506. Human Embryology and Developmental Biology

Prerequisite: ANA 526 or equivalent.

Credit—three hours

This lecture and laboratory course covers classic human embryology with an emphasis on clinical consequences related to congenital anomalies. Additionally, specific lectures in clinical developmental biology with an emphasis on cell and molecular biology supplement the descriptive embryology and include topics currently being researched by Rochester faculty. The course meets each week for three hours during the spring semester, and each weekly session includes two didactic/discussion hours and one hour of laboratory viewing the Carnegie Collection of human embryos. Student participation, a midterm library research presentation, and final essay exam form the basis for student evaluation. (Spring)

508. Applied Human Anatomy

Prerequisite: ANA 526 or equivalent.

Credit—variable

This course is designed for students who wish to review gross anatomy and pursue advanced and specialized anatomical sections in their specific area of interest. This elective is student-directed and tailored to each student’s needs. Students define their learning objectives and enroll for the appropriate time needed (one–four weeks) to accomplish these goals. Students’ time is divided between cadaver dissections and preparation for presentations. The elective facilitates active learning by creating a rich, student-directed learning environment. The weekly presentations formalize this exchange of knowledge and allow the students to be exposed to areas of review that they did not directly dissect. This elective is offered to both fourth-year medical students and advanced graduate students who have previously completed a course in Human Gross Anatomy. (Spring)

509. Teaching Methods in Anatomical Sciences

Credit—two hours

This interactive class offers practical applications in the use of various teaching formats in the anatomical sciences (gross anatomy, histology, embryology) including lecture, gross anatomy lab, histology lab, computer-assisted lab instruction (virtual lab), small group discussion and problem-based learning. The course also provides experience in syllabus preparation, learning objective construction, exam question writing, and course evaluation. Additional lecture topics focus on learning theory and selected topics in educational research relevant to teaching methods and outcomes assessment. Students also prepare and deliver lectures using several different formats (PowerPoint, slides, overheads, and blackboards), and lead small-group venues (e.g., laboratory, case-study sessions). (Summer)

511. Cellular and Molecular Foundations

Credit—two hours

The focus on this course is a practical understanding of gene expression, from DNA replication and RNA transcription and processing to protein translation and trafficking. This knowledge provides students with a foundation for understanding how cells function, both alone and in clusters that form tissues and organs. The coursework also provides students with a knowledge base to evaluate modern molecular biological techniques and their application to neuroscience. (Fall)

512. Cellular Neuroscience

Credit—five hours

Cellular and molecular mechanisms in the nervous system are discussed in detail. Among the topics covered are overview of cellular components and molecular approaches, voltage and transmitter gated ionic channels, second messenger modulation of ionic channels, biochemistry of synaptic transmission, inhibitory and excitatory amino acids, neuronal and glial cell lineage and growth factors, axonal path-finding, and experience-dependent plasticity. Sessions include lectures, discussions, and presentations of papers from the literature. (Fall)

513. Neuroinflammation

Prerequisite: NSC 512 and MBI 473/573 (Immunology) are recommended.

Inflammation contributes to secondary injury following brain trauma or stroke and is often a direct cause of neuropathology in the nervous system. And yet, neuroinflammation may also be critical for regeneration and repair. This course examines the role of inflammation in the central nervous system and highlights common mechanisms of response to a variety of neural insults, including autoimmunity, trauma, neurotoxicology, and neurodegeneration. Further topics include the roles glia, the acquired immune system, and the innate immune system play in response to neural insults in the unique “immune-privileged” environment of the CNS. (Spring, even years)

515. Advanced Topics in Neural Control Movement

Prerequisite: ANA/NSC 531.

Credit—two hours

This advanced graduate course brings students with a basic understanding of the motor system to the forefront of modern
investigation. Topics include movement selection, motor learning, distributed control, basal ganglia function, control of gaze, vestibulo-motor responses, muscle compartmentalization, and others based on student interests. (Spring, even years)

516. Neural Systems and Impairments in Cognitive Function
   **Prerequisite: ANA/NSC 531.**
   **Credit—three hours**
   This course explores the neurobiological basis of diseases affecting cognition, movement, or perception. Recent theories of disease etiology and the neural systems affected by treatment strategies with a focus on relevant animal models are discussed. Examples of topics include schizophrenia, frontal lobe lesions, anxiety and mood disorders, William’s Syndrome, Alzheimer’s disease, Parkinson’s disease, and additional topics requested by the students. (Spring, even years)

517. Advanced Topics in Sensory Systems
   **Prerequisites: ANA/NSC 512 or equivalent and ANA 531 or equivalent recommended.**
   **Credit—three hours**
   This modular course focuses on how sights, tastes, sounds, and other sensory modalities are converted into electrical signals in a form that can be interpreted by the nervous system of invertebrates and mammals. Major discoveries that have shown how sensory signals are detected by specialized receptors and organs are discussed. Each module focuses on transduction—the ion channels, G proteins, enzymes, and second messengers—that produce the responses of sensory cells and ultimately afferent discharge. (Spring)

518. Introduction to Neuroengineering
   **Prerequisite: ANA/NSC 531 or BME 260.**
   This course covers quantitative and computational aspects of neuroscience research. The course begins with a brief review of Hodgkin-Huxley channel dynamics and extends to advanced topics including cable equations, neural circuits, control systems, and neural models of behavior. There is an emphasis on simulation and modeling of both single neurons and neural networks and systems. (Spring)

521. Graduate Journal Club
   **Credit—one hour**
   Provides graduate students with experience in formulating and presenting in a small group setting based upon selections from an area of interest in the scientific literature. Skills involved in literature search, critical thinking, and guiding discussion are honed in a choice of approved journal club venues. (Fall and Spring)

522. Graduate Seminar
   **Credit—one hour**
   Provides experience for graduate students in formulating and delivering oral and poster presentations based upon the students’ own research, lab rotations, or an area of interest in the scientific literature. Skills involved in designing effective visual aids, abstract writing, and organizing content into venue-specific formats are developed, culminating in the presentation of an oral seminar and a poster session open to the academic community. (Fall and Spring)

525. Mind, Brain, and Behavior
   **Credit—eight hours**
   This nine-week course provides a multidisciplinary overview of the structures, functions, and dysfunctions of the human nervous system, integrating both basic and clinical sciences. Basic science portions of this course include the disciplines of neuroanatomy, neurophysiology, neuro- and psychopathology, and neuro- and psychopharmacology. The basic science material is fully integrated with the clinical disciplines of neurology and psychiatry. Overview lectures, problem-based learning sessions, and laboratory exercises introduce the basic and clinical sciences underlying neurological and psychiatric disorders. This course provides a foundation for students interested in understanding and teaching neuroscience in undergraduate, graduate, allied health, and medical school settings. (Weekday mornings, mid-August–mid-October)

526. Human Structure and Function
   **Credit—16 hours**
   This 14-week course provides a rare opportunity to join the medical school curriculum in learning the essential concepts and mechanisms underlying human biology from an integrated perspective, including both basic and clinical applications. Didactic lectures are matched with problem-based learning sessions, problem-solving conferences, and laboratory exercises that introduce students to the systematic study of human structure and function. This integrated course encompasses the disciplines of anatomy, embryology, histology, and physiology. The course includes comprehensive laboratory sessions in gross anatomy and histology, and the qualitative and quantitative aspects of human physiology, including fundamental principles and clinical relevance. Students of the nervous system come to appreciate firsthand the intricacies and ubiquity of the brain’s structural and functional interactions with the various systems of the body, as well as their evolutionary and developmental attributes. The course provides an introductory foundation for students interested in understanding and teaching these disciplines in undergraduate, graduate, allied health, and medical school settings. (Mid-September–late December)

531. Integrative and Systems Neuroscience
   **Prerequisites: NSC 512, NSC 201/BCS 240 or equivalent introductory neuroscience course.**
   **Credit—six hours**
   This course provides a critical overview of current knowledge of systems neuroscience. The topics include an overview of approaches and techniques, a comprehensive account of functional connectivity, transmitters, neurophysiology, and behavioral measures of sensory and motor systems, the basal ganglia, the limbic and hypothalamic systems, as well as memory, attention, and neurobiology of language. In addition, a number of classes deal with neurobiology of disease. (Spring)
581. Teaching Tutorial in Human Structure and Function
Credit—three hours
This course provides an opportunity for students to acquire and develop skills in teaching human gross anatomy and histology. Students may opt for teaching one or both of these disciplines with credits arranged accordingly. For each discipline taught, students are expected to attend and assist in all laboratories as well as attend relevant lectures. Students also provide instruction and presentations to lab groups and assist in preparing and setting up examinations. Although designed primarily for advanced graduate students in neurobiology and anatomy, other graduate students may elect this course if they meet prerequisites. (Fall)

583. Teaching Tutorial in Neurobiology
Credit—three hours
This experience is designed to provide an opportunity for students to acquire and develop skills in teaching and course management in neurobiology (particularly related to Mind, Brain, and Behavior). Students are expected to attend staff meetings, provide instruction in the laboratory, bear responsibility for small group teaching, prepare and deliver formal lectures, assist in the preparation and grading of examinations, and participate in staff-evaluation sessions. Although designed primarily for advanced graduate students in the Department of Neurobiology and Anatomy, other graduates may elect this experience with permission of the instructor. (Fall)

590. Lab Rotations in Neuroscience
Credit—variable
Laboratory rotations are intended to familiarize students with a technique, to gain an appreciation of different scientific approaches to a problem, and to gain exposure to an area of research that eventually leads to a focused area of investigation. Consultation with the advisory committee is required to plan rotation.

591. PhD Readings

592. Neuroscience Journal Club
Credit—one hour
A seminar/reading course on current topics in neuroscience research for year-one students. The objective is to gain experience discussing and critically evaluating primary research articles covering a broad range of topics in neuroscience.

593. Special Topics in Anatomy
Prerequisite: ANA/NSC 512.
Credit—variable
Directed studies of advanced topics in neurobiology, supervised by a faculty member and organized to fit special needs of individual graduate students.

595. PhD Research
Opportunity is afforded for qualified students to undertake research under the direction of members of the staff.

Neuroscience

Professors: Aslin, Bavelier, Bidlack, Carney, Cory-Slechta, DeAngelis, Dewhurst, Dirksen, Duffy, Freeman (Director), Gan, Gelbard, Goldman, Haber, G. Johnson, Knill, Merigan, Mink, Moynihan, Nedergaard, Newlands, Newport, Noble, E. Nordeen, K. Nordeen, O’Banion, Paige, Pasternak, Schieber, Schor, Shragar, Tank, Thornton, Williams

Associate Professors: Bennett, Brown, K. Davis, Dickerson, Freedman, Fudge, Huang, Huxlin, Luebke, Maggirwar, Majewksa, Mayer-Pröschel, Neherk, O’Neill, Olschowka, Opanashuk, Portman, Romanski, Seidman

Assistant Professors: Crane, Halterman, Hayden, Holt, Kammernier, Libby, Tadin, Tieu, White

The Interdepartmental Graduate Program in Neuroscience provides a comprehensive, research-intensive training experience for students seeking a PhD degree in the study of the nervous system. Over 60 faculty members serve as mentors for students, representing basic science and clinical departments and centers from the School of Medicine and Dentistry and the schools of Arts, Sciences & Engineering. Faculty research interests span all major themes in neuroscience including neural cell signaling and communication; learning, memory, and adaptive plasticity; neurobiology of disease; neurodevelopment and aging; neuroengineering; neurogenetics; sensory, motor, and integrative systems neuroscience; and neuroregeneration and repair. Collaborations across these themes are a hallmark of the program, providing students the opportunity to design thesis projects without regard to traditional boundaries.

During the first year, students engage in a rigorous curriculum in cellular and systems neuroscience that builds a solid foundation for subsequent, more specialized coursework tailored to the individual career and research interests of each student. In addition, first-year students complete three laboratory rotations that, through active participation in a research project, provide an insider’s view of the research interests, laboratory environment, and mentoring style of potential thesis advisors. At the end of the first year, students choose a thesis advisor and begin developing and carrying out their dissertation research. Training in subsequent years occurs largely through active participation in laboratory research, journal clubs, and seminars, and at local, national, and international scientific meetings. Students are awarded the PhD degree upon successful defense of scholarly research described in a publishable dissertation.
503. Neuroscience Student Seminar  
Credit—one hour  
This course provides students a forum for developing and refining their oral presentation skills and for getting feedback on their research. Students deliver an annual seminar on their thesis research. Following each presentation, audience members complete an evaluation to provide the presenters with feedback on various aspects of their presentation. (Fall and Spring)

508. Neural Plasticity in Learning and Development  
Credit—three hours  
This course provides an examination of neural plasticity in development as well as in adult learning and memory. Specific topics are approached from the complementary perspectives that emerge from work in molecular, cellular, behavioral, computational, and psychophysical fields of neuroscience research. (Spring, alternate years)

511. Human Brain Anatomy  
Prerequisite: NSC 512 or permission of instructor.  
Credit—one hour  
This introduction to human brain anatomy is based on a series of laboratories developed for medical students, although the emphasis for this course is on relating structure to function rather than diagnosing neurological conditions. The major goal is to gain an understanding of basic brain structures from standpoints of anatomy, organization, and function. A series of lectures provides additional information and explanations to complement concepts learned in the laboratories. (Spring)

512. Cellular Neuroscience  
Credit—five hours  
This course provides an advanced understanding of the biochemical, molecular, and cellular properties of the nervous system as well as its organization and development. The first section covers the electrical properties of neurons, the molecular properties of ion channels, and the organization of receptors and channels at the synapse. This is followed by an explanation of the biochemical and pharmacological properties of neurotransmitters and their receptors, sensory transduction mechanisms, and mechanisms of signal transduction in neurons. The final unit discusses the molecular and genetic processes that govern nervous system development. (Fall)

513. MR Imaging: from Spins to Brains  
Credit—three hours  
This course introduces students to the physics of MR imaging and reviews its application to medical imaging. The course discusses how the MR technique can take advantage of physiological principles and tissue structure to provide diagnostic image for clinicians and researchers and insights into brain function. In particular, students are introduced to functional brain imaging and related issues in data analysis. (Fall)

525. Biology of Neurological Diseases  
Prerequisite: NSC 512 or permission of instructor.  
Credit—three hours  
This course explores the neurobiological basis of human neurological disease, emphasizing the relationship between behavioral dysfunction and neuropathology or neural dysfunction. While this is an overview, we emphasize those diseases for which significant information is available in terms of genetic or molecular control of disease mechanisms or therapeutic approaches. The course is designed for graduate students in neuroscience or in other disciplines who have a background in neurobiology. (Spring)

531. Integrative and Systems Neuroscience  
Prerequisites: NSC 512 or NSC 201/BCS 240 or (equivalent introductory neuroscience course) with permission of instructor.  
Credit—six hours  
This course provides a critical overview of current knowledge of systems neuroscience. The topics include an overview of approaches and techniques, a comprehensive account of functional connectivity, transmitters, neurophysiology, and behavioral measures of sensory and motor systems, the basal ganglia, the autonomic limbic and hypothalamic systems, as well as memory, attention, and cognition. (Spring)

547. Introduction to Computational Neuroscience  
Credit—three hours  
This course reviews recent progress in computational theories of the brain, emphasizing theories of representation and computation in neural circuits. The course begins with biophysical models of neurons and ends with models of complex cognitive functions such as sensory motor transformations or sentence processing. (Spring)

581. Teaching Tutorial in Neuroscience  
Credit—three hours  
This experience provides an opportunity for students to acquire and develop skills in teaching and course management in neuroscience. Students assist in teaching NSC 201 or NSC 203 and are expected to attend staff meetings, provide instruction in the laboratory, bear responsibility for small-group teaching, assist in the preparation and grading of examinations and papers, and participate in staff-evaluation sessions. (Fall and Spring)

590. Lab Rotations in Neuroscience  
Credit—to be arranged  
Laboratory rotations are intended to familiarize students with the individual laboratories and areas of research where they may eventually want to pursue their thesis work. Rotations also provide an opportunity to learn and master new techniques and to gain an appreciation for different scientific approaches to a problem. Rotations are planned in consultation with the first-year faculty advisor. (Fall and Spring)
591. PhD Readings  
**Credit—to be arranged**

PhD Readings are individualized readings courses in which students gain in-depth familiarity with theoretical issues and experimental approaches on a specific topic in neuroscience. The course is guided by an instructor selected by the students from members of the neuroscience faculty. The instructor meets with the students on a weekly basis to assist in the selection of relevant readings and to discuss the key issues. Grades are based on a term paper or on an oral examination administered by the instructor and other participating faculty. (Fall and Spring)

592. Neuroscience Journal Club  
**Credit—one hour**

This is a seminar/reading course for first- and second year neuroscience graduate students focused on current topics in neuroscience research. The objective is to gain experience discussing and critically evaluating primary research articles covering a broad range of topics in neuroscience. (Fall and Spring)

595. PhD Research  
**Credit—to be arranged**

Center for Oral Biology

Professors Quivey (Director), *Shuttleworth  
Associate Professors *Haidaris, Hsu, *Koo,*Yule  
Assistant Professors Lemos, Ovitt  
Research Assistant Professors Abranches, *Friedman, Gonzaléz-Begné, Klein, Vonica  
Instructor Roger  
Professor Emeritus Bowen, *Marquis

The principal objective of the Center for Oral Biology is to train dentists and other qualified and interested persons in research related to oral health and disease for academic careers. In pursuit of these aims, the Center cooperates closely with the basic science departments of the School of Medicine and Dentistry and the College. There is also close cooperation with the Eastman Department of Dentistry and other clinical departments such as medicine, pediatrics, and pathology and laboratory medicine. Joint degree programs are offered with these various departments.

Graduate students who hold appointments in the Center for Oral Biology may work for the Ph.D. degree in disciplines including anatomy, biochemistry, biology, biophysics, genetics, microbiology and immunology, neuroscience, pathology, pharmacology, physiology, or toxicology. Entrance requirements are in accordance with the policies of the individual departments, centers, and programs. The Ph.D. candidate is registered in the department or center in which the degree will be granted. Classes and seminars are attended, and a research program directed toward the solution of some problem pertinent to oral science is carried out in the appropriate basic science department or center. Guidance and supervision are available from the faculty members of the Center for Oral Biology, consultants on the staff, and members of the collaborating departments and centers.

The master in the Dental Sciences Program is primarily directed to students who have already completed dental school, though the program is open to non-dentists who have completed a bachelor’s degree and demonstrate a strong interest in problems related to oral biology and disease. The program consists of four areas of emphasis, or tracks, including the following: Infectious Disease, Regenerative Medicine and Exocrine Gland Biology, Developmental Biology and Genomics, and Clinical/Translational Research. Studies leading to the master’s degree in dental sciences will typically cover two to three calendar years and require a total of at least 30 hours of credit consisting of 18 hours of didactic coursework and 12 hours for research. Pre-doctoral candidates will be considered for the master’s program in special circumstances. Each student will be required to participate in didactic courses and seminars offered by the University of Rochester Medical Center. In addition, all candidates must choose a particular area in the sciences as a minor (biochemistry, pharmacology, etc.) for advanced study and to develop knowledge in this field by attending appropriate courses. The candidate must also conduct a research project in an area of oral biology. The

* Primary appointment in another department
results of this work must be presented in a thesis acceptable to the candidate’s committee. Fellowship stipends sufficient to meet living costs are available to selected students on a competitive basis.

The Training Program in Oral Sciences provides financial support for pre- and postdoctoral (D.D.S. or Ph.D.) fellows to receive training for three to five years. The objective of the program is to prepare creative, imaginative, and highly skilled professionals in the field of oral biology.

The courses available to support training are quite broad in their diversity. A sampling of courses offered in the training programs of the Center for Oral Biology are shown below.

414. Mechanisms of Microbial Pathogenesis  
Prerequisite: MBI 220, 221 or permission of instructor.  
Credit—three hours  
The molecular mechanisms by which bacteria cause disease are examined. The emphasis is on understanding how bacteria colonize the host, evade host immune defenses, and cause damage to the host, as well as understanding the regulation of synthesis, structure, function, and mode of action of bacterial toxins.  
(Spring, odd years)

493. Fundamentals of Oral Microbiology  
Prerequisite: permission of instructor.  
Credit—two hours  
The major groups of microorganisms causing oral disease are reviewed with emphasis on basic biology, genetics, physiology, and pathogenic mechanisms.  
(Fall, odd years)

495. M.S. Research  
Prerequisite: D.D.S., D.M.D., or equivalent.  
Credit to be arranged  
The research program of the dental fellows is usually directed toward the solution of some problem pertinent to dentistry. Laboratory facilities are available in the Center for Oral Biology, the Eastman Department of Dentistry, and the preclinical departments of the School of Medicine and Dentistry. (Ph.D. research is registered with the appropriate preclinical department.)

501–504. Dental Research Seminar  
Prerequisite: permission of instructor.  
Credit—one hour each term  
The purpose of this series is to provide experience to participants in preparing, organizing, and presenting material to a critical audience. The fall semesters are devoted to a systematic review of recent significant research developments in one of the basic sciences fundamental to oral biology. In the spring semesters, the students report on original research. Required of all graduate students in oral biology and open to other graduate students and dentists.

556. Biology of the Periodontium  
Prerequisite: permission of instructor.  
Credit—one hour  
Stressing the biological behavior of the periodontium, the course reviews the fundamentals as well as the latest developments in periodontal research. Topics covered are the development, morphology, and physiology of the periodontal tissues; the epidemiology, etiology, and histopathology of periodontal diseases, plus current concepts regarding mechanisms of periodontal tissue destruction and repair.  
(Spring, odd years)

557. Epidemiology II: Research Design and Analysis  
Prerequisite: permission of instructor.  
Credit—one hour  
This is the second course in the pair with 570. Students are introduced to epidemiological research design and analysis of results.  
(Spring)

558. Growth and Development  
Prerequisite: permission of instructor.  
Credit—one hour  
This series covers the prenatal embryogenesis and postnatal growth and development of the craniofacial complex. Mechanisms of growth control, the development of occlusion, and methods of study and timing are presented. Clinical implications for normal and abnormal facial development are discussed.  
(Spring, odd years)

563. Pharmacology and Therapeutics  
Prerequisite: permission of instructor.  
Credit—one hour  
Pharmacotherapeutics of drugs most often used in dentistry are reviewed with emphasis on critical analysis of the related literature and current directions in pharmacological research.  
(Fall, odd years)

570. Introduction to Dental Epidemiology and Research Design  
Prerequisite: permission of instructor.  
Credit—one hour  
Students are introduced to the fundamentals of epidemiology. Emphasis is placed on the natural history of common dental diseases.  
(Fall)

579. Saliva and Salivary Glands  
Prerequisite: permission of instructor.  
Credit—two hours  
This course gives students an understanding of the fundamental biology of the salivary glands. The regulation of salivary gland physiology is discussed, as is the structure/function relationship of salivary proteins and lipids. The molecular basis of salivary gland gene expression is explored. The etiology, pathogenesis, and consequences of salivary gland diseases are also discussed.  
(Spring, even years)
580. Fundamentals of Dental Caries  
*Prerequisite: permission of instructor.  
*Credit—one hour  
This course presents the latest developments in many aspects of dental caries, from the most fundamental basic science to clinical applications. (Fall)

589. Mucosal Immunology  
*Prerequisite: MBI 473 or permission of instructor.  
*Credit—two hours  
This course focuses on immunological mechanisms pertinent to the oral cavity. Subject areas include nonspecific and specific immunological factors and the effects of mucosal immunity on oral health. There is an emphasis on the molecular and cellular aspects of immunology as they relate to the oral cavity. (Spring, odd years)

593. Complex Carbohydrates  
*Prerequisite: permission of instructor.  
*Credit—one hour  
The synthesis, structure, and function of complex carbohydrates is considered with emphasis on recognition phenomena. (Spring)

Pathology and Laboratory Medicine

*Assistant Professors* A. Friedman, A. Kiernan, R. Libby, C. Ovitt, C. Proschel, J. Que  
*Research Assistant Professor* R. Eliseev  
*Adjunct Assistant Professor* W. Ricke

The Department of Pathology and Laboratory Medicine offers a program of education and research leading to the degree Doctor of Philosophy in pathology. While the program is sponsored by the Department of Pathology, the participating faculty are drawn from at least 13 departments. This provides diverse education and research experiences and thesis opportunities for the student. The graduate program in pathology is designed for the student who is interested in applying the latest advances in cell biology, biochemistry, and molecular biology to the understanding of human disease mechanisms. Pathology is a bridging discipline between basic research and clinical medicine. The objective of the graduate program in pathology is to prepare the student for successful, independent careers in research and teaching. Through coursework, seminars, and research experiences, the student will be well prepared to address the complex but rewarding problems in human disease in either an academic or industrial setting.

The first year of the Pathways of Human Disease Graduate Program in Pathology (DWD) is designed to give trainees a strong foundation in biochemistry (IND 408), cell biology (IND 409), molecular biology/genetics (IND 410), and in fundamentals of pathobiology (PTH 509/510). The course requirements are common to most degree programs in the first year and afford the students maximum flexibility. At the end of the first year of study, after successful completion of course requirements and three lab rotations, students designate a thesis advisor. Most students choose to remain in the graduate program in pathology. The thesis advisor need not be a member of the PWD Graduate Program faculty but must provide a strong training and educational environment. Students follow a disease-oriented curriculum in elective studies and in advanced coursework during the second year.

The faculty of the graduate program in pathology represent at least 16 departments within the Medical Center and offer many exciting research opportunities to students. Faculty research interests include cellular structure and function, nuclear receptors, gene regulation, cell-cell interactions, chemotaxis, extracellular matrix,
genetic and molecular analysis of chromosome structure and gene expression, growth factors, lipoprotein structure and function, oncogene and tumor susceptibility, and gene products. Diseases under active investigation include diabetes; cardiovascular disease; osteoporosis; breast, prostate, and bladder cancer; and arthritis to name just a few. Several experimental approaches used by our students include production of new molecular and immunological probes for genes and their products, quantitative high-resolution image analysis of cells and tissues, quantitative single-cell measurements by flow cytometry and cell sorting, receptor biology and signal transduction, and RNA processing.

504. Current Topics in Experimental Pathology
Prerequisite: permission of course director.
Credit—one hour
This course uses the seminar format to introduce students to diverse experimental and intellectual approaches to studying disease processes. Students alternate with investigators from both outside and within the University in presenting their current research at the Pathology and Laboratory Medicine seminar series. The Student Seminar Series is also a component of PTH 504. Each student gains experience in oral presentations by presenting his or her research work to the faculty and fellow students on a yearly basis. (Fall and Spring)

507. Cancer Biology
Prerequisite: permission of course director.
Credit—three hours
The goal of this course is to provide a solid background and current understanding of cancer biology and cancer-related research. The lectures will cover key topics in cancer biology, including intrinsic regulatory mechanisms of cancer cell proliferation, the impact of microenvironment on tumor growth and metastasis, and the diagnosis and prognosis of cancer. Leading scientists in the cancer research field deliver lectures on each topic and lead in-depth discussions centered on groundbreaking findings. The advanced-level course emphasizes original experiments and critical thinking and reading of the primary literature rather than abstract facts and memorization. Active participation and in-class discussions among students are expected. This course is offered as a mandatory requirement for postdoctoral fellows on the Cancer Center Training Grant and as an upper-level elective for graduate students campus-wide. (Spring)

509/510. Pathways of Human Disease I and II
Prerequisite: permission of course director.
This two-semester course is the signature course of the graduate program in pathology. Its objective is to provide students with an introduction to human disease processes with an emphasis on the molecular and genetic mechanisms of disease. Students learn the basic anatomy, histology, and physiology of all major organ systems in the context of examples of human disease. They complete the course with an understanding of the basic principles of human disease processes at the whole animal, organ, cellular, and molecular levels. They also gain insight to current applications and limitations of modern diagnostic medicine and the importance of basic translational research. Lectures are complemented by interactive labs and journal clubs to expand on what is taught in class. There are three weekly sessions—two didactic and one laboratory. Laboratory exercises use the vast resources of the Medical Center to provide practical experience in current and cutting-edge application of biomedical science to medicine. (Fall I, Spring II)

571. Molecular Basis of Human Disease
Prerequisite: permission of course director.
Credit—three hours
This course provides translational medicine-oriented lectures to help students understand the utilization of molecular, cellular, and genetic approaches to investigate human diseases and disease-related animal models. Significant emphasis is placed on the current understanding of disease processes, limitations, and strategies for innovative experimentation that should lead to breakthrough discoveries and cures. Discussions address various diseases including, but not limited to, cardiovascular, neurological, and hematological abnormalities; autoimmunity; endocrine defects; and cancer. Each week covers one specific topic that is composed of a lecture and a journal club. Students are assigned scientific papers of interest and present and discuss these papers with their peers at the second session provided by each faculty. (Fall)

595. PhD Research
Credit to be arranged
PhD research is done under the direction of a faculty member of the Medical Center with the approval of the graduate program in pathology.
Pharmacology and Physiology

Research Associate Professor *Krieger
Research Assistant Professors Lehman, Malik, Yarotskyy
Adjunct Professor *Sheu
Adjunct Associate Professor Anaizi
Adjunct Assistant Professor Gehret, *Ma, *Morse
Professors Emeriti Anders, Begenisich, Blair, Hinkle, Peracchia, Rivera-Calimlim

The objective of the graduate programs in pharmacology and physiology at the University of Rochester is to provide a thorough understanding of basic pharmacology and physiology and to prepare graduates for careers as investigative pharmacologists and physiologists. The programs include coursework in pharmacology, physiology, and the basic biomedical sciences; participation in the departmental seminar program; and original laboratory investigations in pharmacology or physiology. The Ph.D. program can lead to either a Ph.D. degree in pharmacology or a Ph.D. degree in physiology. The Ph.D. degree is awarded upon completion of scholarly work and research described in a publishable dissertation.

In general, a bachelor’s degree in biology or chemistry is the preferred undergraduate training for entrance. These courses are ordinarily required for admittance to the Ph.D. program in pharmacology and physiology: introductory courses in organic and physical chemistry, biology and biochemistry; courses in molecular biology, statistics, and physics are recommended, but not required. Applicants are required to submit the results of the Graduate Record Examination. First-year graduate students typically enroll in required core courses in biochemistry (IND 408), cell biology (IND 409), and molecular biology and genetics (IND 410); and in courses (PHP 403, 404, and 502) that fulfill the degree requirements for the Ph.D. programs in pharmacology or physiology. In addition, all graduate students must complete the Ethics and Professional Integrity course (IND 501). Second-year courses are selected from a menu of electives.

403. Cell and Molecular Physiology
Credit—three hours

This course is aimed to provide an introduction to the fundamental principles of modern cell and molecular physiology—the basic concepts in the field, the principal research questions, and common methodologies. Emphasis is on a quantitative approach wherever possible, and the implications of the cellular and molecular principles addressed to the overall physiology of the body, in both healthy and diseased states, are discussed. Course content particularly focuses on cardiovascular, neurobiological, and epithelial/exocrine systems. (Fall)

404. Principles of Pharmacology
Prerequisite: PHP 403 or permission of course director.

Pharmacology is one of the vital disciplines in biomedical sciences. It employs the multidisciplinary knowledge in biochemistry, cell biology, chemistry, genetics, neuroscience, pathology, physiology, toxicology, and clinical medicine, to elucidate the mechanisms of action of drugs in treating human diseases. This course represents a collective endeavor of our faculty to the teaching of graduate and senior undergraduate students at the University of Rochester. It focuses on the fundamental principles of pharmacology, neuropharmacology, cardiovascular pharmacology, and contemporary approaches to drug discovery and design. (Spring)

400. Topics in Vascular Biology
Prerequisite: graduate physiology recommended and permission of instructor.
Credit—two hours

This course provides an in-depth coverage of selected topics in vascular biology. Major topics and concepts are introduced in the context of current literature. These include vascular functional anatomy, angiogenesis, hemodynamics, vascular control mechanisms, vessel-blood interactions, signaling, mechanotransduction, leukocyte-endothelial cell interactions, vascular disease, and gene therapies. (Alternate springs)

447. Signal Transduction

Cellular signal transduction is one of the most widely studied topics in the biomedical sciences. It has become clear that cells have multiple mechanisms for sensing the environment and converting the external signals into intracellular responses. The goal of this course is for students to learn modern concepts in signal transduction. The lectures cover a spectrum of topics ranging from basic principles and mechanisms of signal transduction to contemporary techniques for doing research in this area. (Spring)

491. MS Reading
Credit to be arranged

495. MS Research
Credit to be arranged

502. Seminar
Credit—one hour each term

Research presentations given by students, staff, faculty, and outside guests. Organized survey of selected fields may be presented upon request.

* Primary appointment in another department
550. Ion Channels and Disease
Credit—two hours
It has become increasingly (and not surprisingly) clear that ion channel and Ca\textsuperscript{2+}-signaling proteins are often the targets of disease mechanisms and therapeutic drugs. This course is designed to provide an advanced understanding of the basic properties of ion channels and Ca\textsuperscript{2+}-signaling systems and an appreciation of some of the functional modifications in these proteins produced by genetic defects. These topics are examined through readings of classic and current papers of the original literature that is integrated with didactic material where useful. It wasn’t that long ago that many folks weren’t sure that ion channels were actually channels. The application of mathematics and physics to electrophysiology was quite successful in uncovering many of the structural features later confirmed by the more direct method of X-ray crystallography. Of course, at present, the relevant crystallographic techniques cannot produce time-resolved pictures, so essentially, all of our understanding of dynamic ion channel function comes from combining some form of voltage clamp technique with other methods. The first several weeks the course covers some of these “biophysical” approaches that are widely used in investigations of ion channel structure and function. (Alternate springs)

593. Special Topics in Pharmacology and Physiology
Credit to be arranged
Directed studies in the field of pharmacology or physiology, supervised by a faculty member and organized to meet the needs of individuals or small groups of graduate students. May involve supervised readings, laboratory exercises, or organized discussions.

Public Health Sciences
Professors’ Brown, Fisher (Chair), Pearson
Associate Professors Adams, Chin, Dolan, Dozier, Fernandez, Li, McIntosh, Noyes, Ossip, Temkin-Greener, van Winjgaarden, Veazie
Assistant Professors Alio, Block, Mittal, Tacci, Zhang
Professors Emeriti Barker, Kunitz, Zimmer

The Department of Public Health Sciences offers programs of study leading to the degrees of Master of Public Health, Master of Science in both clinical investigation and translational research, and Doctor of Philosophy in both health services research and policy in epidemiology. The master’s programs are designed to train current and future health professionals by developing and enhancing their planning, evaluative, research, and management skills. The doctoral programs train students to teach and conduct independent research in a specific field of study.

The MPH is 44 credit hours. It can be completed in two years of full-time study. The master of science in clinical investigation (MS-CLI) is 33 credit hours and the master of science in clinical translational research (MS-CTR) is 35 credit hours. They both can be completed in one full-time or two part-time years of study. Required courses for both tracks include epidemiology, biostatistics, research methods, social and behavioral factors affecting health and illness, health policy, management and evaluation of health service organizations, environmental and occupational health, and SAS programming. All master’s students complete a research project in the area of public health and/or population research using epidemiological and other analytic methodologies. The project is designed, carried out, analyzed, and written by the student under the supervision of a faculty preceptor and an advisory committee.

The doctoral program in health services research and policy is designed to produce researchers who generate knowledge used in solving health care problems. The course curriculum focuses on two main goals. First, it focuses on developing skills in the use of research methods (e.g., study design, statistics, decision analysis, risk adjustment, and cost-effectiveness analysis) and theory (e.g., economics, psychology, and systems theories) to address relevant questions. Second, it focuses on providing an extensive knowledge-base in substantive areas related to the institutions, structures, and functioning of the U.S. health care system. The dissertation process focuses on producing careful scientific thinkers who can integrate these skills and knowledge to identify and address vital research questions, and who can create and test theory-based policy and clinically relevant explanations of important health care phenomena.

The doctoral program in epidemiology is designed to foster scholarly achievement in the area of disease prevention and health promotion through the conduct of independent community and population research. The formal curriculum emphasizes the sequential process of reasoning that is inherent

* Primary appointment in another department
412. Survey Research
Prerequisite: PM 415 or permission of the instructor.

This course presents students with an overview of the role of survey methods and tools in the research process, with a particular focus on survey research applications in health care research and epidemiology. The course incorporates an integrated perspective, which includes a qualitative approach to conducting appropriate and accurate survey research. Students participate in all stages of the survey research process through application of homework assignments. (Spring)

413. Field Epidemiology
Prerequisite: Introduction to Epidemiology or permission of the instructor.

This course provides an overview of the practical applications of theoretical epidemiological concepts in the study of the distribution of diseases and their causes in populations. Emphasis is on the hands-on discussion of basic methods in epidemiologic research, including literature review; study design selection; measurement of disease; selection of relevant variables; development and administration of questionnaires; quantitative data analysis; and reporting study findings. These concepts are discussed in the context of case studies and special topics such as outbreak investigations, cancer cluster investigations, and meta-analysis. (Spring)

414. History of Epidemiology

The overall goal of this course is to focus the attention and raise the awareness of students on the historical perspectives of epidemiology, as a basic science, and shows the inter-relationship between epidemiologic methods and intellectual, social, political, and technological progress that has occurred throughout history. All of these events are crucial to a deeper understanding how diseases have influenced history and what major contributions epidemiologists have made to medicine. This course emphasizes the relationship between epidemiology and other scientific disciplines by demonstrating the influence of methodological techniques used by epidemiologists. Additionally, the framework of this course fosters an appreciation for the role of epidemiology in society through its impact on public health and the impact of society and its norms on the growth of epidemiology. (Fall)

415. Principles of Epidemiology

Introduction to epidemiology is intended to provide an overview of concepts dealing with the study of the distribution of diseases and their causes in populations. It defines epidemiologic terms, introduces methods used to describe diseases in populations, provides an overview of ways to determine the causes of disease, and applies epidemiologic principles to the evaluation of preventive and therapeutic interventions. This is carried out by lecture presentations supported by laboratory problems and small group discussions. The course uses L. Gordis, *Epidemiology*, 4th Edition. Philadelphia: W. B. Saunders Co., 2008, as a textbook, supplemented with additional readings. (Fall)
416. Advanced Epidemiologic Methods  
Prerequisites: PM 415 and one semester of graduate-level statistics.

This course provides an in-depth coverage of the quantitative methodologic issues associated with population-based epidemiologic research. Issues specific to study design, conduct, and analysis are emphasized. Topics covered include issues in study design, topics in measurement, methods of data collection, confounding, effect modification, and multivariate analytic techniques. (Fall)

417. Molecular Epidemiology

Using the same paradigm as traditional epidemiology, this course explores the opportunities for the use of increasingly powerful biologic markers of exposure, disease, and susceptibility to provide high-resolution answers in relation to the causes of disease. The course focuses on the practice of molecular epidemiology as an interdisciplinary science, and the use of biologic markers to advance our knowledge about health and disease among groups of people in a manner that is appropriate for inference to larger populations. (Fall)

418. Cardiovascular Disease Epidemiology and Prevention

At the completion of the course, students are able to demonstrate their knowledge of cardiovascular disease epidemiology and prevention by listing and/or discussing the proven risk factors for coronary heart disease (CHD) and the seminal studies leading to their discovery. Other important topics students should describe are the emerging risk factors for CHD, strategies and interventions for preventing CHD, and the difference between risk markers and risk factors. Students should also demonstrate an ability to identify and verify that a risk marker is truly independent, recognize the known and suspected risk factors for stroke, and the current controversies in CVD EPI and prevention and how they have arisen. (Fall)

419. Recruitment and Retention of Human Subjects in Clinical Trials

Through a combination of didactic presentations, in class group exercises and case examples from the literature, the sequential steps in program evaluation design decisions are discussed and critiqued. Students conduct a review of program evaluation literature within a topic of interest and incorporate it into class participation and final papers. Readings from the literature and online sources complement in-class course content. (Every other fall, even years)

420. American Health Policy and Politics

This course examines the formation and evolution of American health policy from a political and historical perspective. Concentrating primarily on developments from 1932 to the mid-1990s, readings and seminar discussions focus on political forces and institutions and on historical and cultural contexts. Among the topics covered are periodic campaigns for national health insurance efforts to rationalize and regionalize health care institutions, the creation of Medicare and Medicaid and the further evolution of these programs, the rise to dominance of economists and economic analysis in the shaping of health policy, incremental and state-based vs. universal and federal initiatives, and the formation and failure of the Clinton administration’s health reform agenda. (Fall)


This course examines the organization, financing, delivery, and performance of the U.S. health care system. The inherent trade-offs between access to care, cost, quality, and outcomes are considered from the perspective of the main actors in the system, i.e., patients, providers (physicians, hospitals, etc.), health plans, insurers, and payers. Topics include need and access to care; health care insurance and financing; Medicare and Medicaid; managed care; service delivery; long-term care; public health; quality of care, and others. The aim of the course is to help students deepen their understanding of the health care system, strengthen their ability to synthesize the literature and assess key current policy issues, and to further develop their critical thinking skills. (Fall)

422. Quality of Care and Risk Adjustment

The purpose of this course is to explore the various methods and opportunities available to track and assess outcomes of clinical practices and medical technologies. The material covered introduces the framework, analytic approaches, databases and settings available for studies addressing patient health outcomes and satisfaction, practice patterns, clinical interventons and strategies that constitute the content of health care. The course focuses on the use of patient populations and databases as laboratories for the generation of new knowledge and information. (Fall)

424. Epidemiology and Prevention of Chronic Diseases
Prerequisite: PH 103 or 415.

This course offers an overview of the epidemiology of selected chronic diseases (cardiovascular diseases, cancer, chronic respiratory diseases, and chronic neurological conditions) and the methods to study them. By the end of the course, students should have sufficient understanding of the pathology, diagnostic classification, screening, risk factors, and treatment of these diseases.

425. Health Promotion and Preventive Medicine

This course provides the learner with a solid foundation and appreciation for primordial, primary, secondary, and tertiary disease prevention strategies on both an individual (patient and provider) and population-wide basis (society as a whole). The overarching theme of the course is to impress upon the learner the importance of and need for preventive health behavioral interventions and the positive impact healthy behavior change can have on our society as a whole on an environmental, economical, and social level.

426. Social and Behavioral Medicine

The course focuses on (1) the application of behavioral, sociological, and anthropological science approaches to the etiology, prevention, treatment, and management of physical disease and illness; and (2) the identification of relationships among
behavioral, sociological, anthropological, and biological factors in health. Students acquire a familiarity with current theoretical and methodological issues in social and behavioral medicine, develop an understanding of evidence-based health promotion/disease prevention interventions in different content areas, consider cross-cultural perspectives, and develop critical thinking skills necessary to evaluate the research literature in these areas. (Fall)

428. Health Services Research Seminar
A noncredit course required of all doctoral and postdoctoral students. A variety of topics is presented for discussion by faculty and students.

438. Practical Skills in Grant Writing
This course is intended to provide the student interested in a career in the life sciences with practical skills related to procuring external support for research. The course content includes a variety of didactic lectures on grant-related topics, discussion sessions with the opportunity to examine grants that others have written, examination of tools and resources available to assist in grant writing, and the opportunity to write a grant for support of the student's own research project and have it critiqued. At the end of the course, the enrollee should be able to write a research grant. (Spring)

442. Nutritional Epidemiology
This course is designed to give students the tools to critically review the nutritional epidemiologic literature and to conduct epidemiologic studies of diet, nutrition, and disease. Concepts on nutritional epidemiology are applied to nutrition and nutritional-related disorders prevalent in the United States and globally (e.g., descriptive epidemiology of breast-feeding, obesity). Prerequisites: introductory courses in epidemiology and statistics. (Spring)

445. Introduction to Health Services Research and Policy
The course reviews the historical development and multidisciplinary nature of HSR, explores the implications of a broader population-based perspective on HSR, illustrates the basic concepts and methods of social science research as applied to the field. Includes an overview of major theoretical foundations of HSR and enhances students’ abilities to critically read and evaluate the research design, methodological approaches, and conclusions of HSR studies.

448. Health Policy Analysis
This course introduces the students to a variety of tools that are used to analyze governmental health policy. The tools and concepts are those found in economics (e.g., market analysis, efficiency), political science (e.g., analysis of voting behavior, interest groups, public opinion), and econometrics (e.g., regression analysis). Class discussions are based primarily on selected journal articles. (Fall)

450. Governance and Management of Community Health Services Organizations
This course focuses on the governance and executive management of nonprofit health and human service organizations with emphasis on those that provide community-based services. Each student selects one such organization for intensive study of its mission, stakeholders, strategic issues, and community impact. The student submits a report on that organization and an analysis of one of the community elements, e.g., government, donors, regulation that influence nonprofits. (Fall)

451. Infectious Disease Epidemiology
Infectious diseases are a main contributor to global morbidity and mortality. Through course readings and small group discussion, participants gain a better understanding of the distribution, transmission, and pathogenesis of infectious diseases and how this knowledge can be applied to the prevention and control of pathogens. This course examines the epidemiology of infectious diseases within an ecological and evolutionary framework. Infectious agents are studied in terms of their own life cycle, immunology, ecology, evolution, molecular biology, and similarities of microbial pathogenicity. Part I of this course affords students the opportunity to acquire and use the methodological skills that will enhance their investigation of the transmission of specific infectious agents during Part II of the course. Part III concentrates on examining the global burden of infectious diseases. Students are encouraged to recognize that understanding the epidemiology of infectious diseases provides a means of preventing infection through public health measures rather than through vaccination, which has proven largely to be unsuccessful (e.g., HIV) or to be of limited effect (hepatitis B and C) over the last decade. (Spring)

452. Community Health Improvement Practicum
The course aims to educate students in the appropriate knowledge, attitudes, and skills necessary for developing the connection between students and the Rochester community, specifically in the connection between community and health. The course also is designed to help them become key partners in the community who are able to help effect positive changes in health on a broader scale. (Fall)

456. Advanced Health Economics I: The Industrial Organization of Health Care Markets
Prerequisite: microeconomics (ECO 207 or ECO 471) and calculus
This course develops key theoretical concepts of industrial organization and applies the concepts to health care markets. Topics covered include theory of the firm, typology of markets, strategic behavior, integration, the role of information, and regulation. (Fall)

458. Qualitative Health Care Research
A community’s health is not just determined by individual health behaviors, but also by cultural beliefs and forms of social organization. Traditional quantitative methodologies, which have been so powerful in understanding biological phenomena, have limited explanatory power in analyzing sociocultural phenomena.
Qualitative methods, long used in the social sciences, allow for the collection, analysis, and interpretation of social and cultural data that quantitative methods cannot adequately reach. In addition, qualitative methods can function as an essential adjunct to quantitative methods by hypothesis generation or identifying lay terminology for accurate survey developed. This course covers standard qualitative methodologies through a discussion of relevant literature, class exercises, and a class project. (Spring)

460. Master’s Essay
This research project is designed, carried out, analyzed, and written up by the student under supervision of and consultation with an essay advisor and an advisory committee.

461. Program Evaluation for Public Health
This course provides MPH students with practical skills to organize and conduct credible and useful evaluations of health or human service projects or programs. Focusing on methods, this course helps students design and critique approaches to answer two key questions central to program evaluation: Is this program working as intended? Why is this the case? Students learn the theories behind program evaluation and how to prevent or overcome common evaluation planning and implementation challenges and pitfalls. Students also develop additional skills in designing programs, writing objectives, working with stakeholders, establishing appropriate measures/data gathering tools, designing implementation specifications, analyzing results, and presenting findings. (Summer)

462. Laboratory Methods for Translational Research
Objectives: A number of different laboratory methods are needed for the various facets of translational research: discovery of pathways involved in diseases, development of screens for molecules that can target these pathways, biomarker discovery, and even more routine patient screening and outcome measures. This course explains the basis of commonly used laboratory technologies, including genomics, proteomics, transgenic mouse models, basic molecular biology methods, cell sorting, chromatography, etc. Both lectures and discussions of the primary literature are used to survey these methods. The goal is for the students to have a basic understanding of a broad range of methods (both advantages and pitfalls), not to learn detailed protocols for any particular technology. (Fall)

463. Introduction to Mathematical Statistics, Part I
The goal of this course is to familiarize students with basic elements of probability and mathematical statistics. At the completion of this course, students are familiar with set theory and notation and with special distributions, both discrete and continuous; understand probability theory, and how to approach both functions of random variables and limit theorems in statistics. (Fall)

464. Introduction to Regression Analysis, Part II
The course focuses on becoming familiar with the theory of ordinary least squares regression analysis and its assumptions as well as the necessary alterations required to conduct valid analysis when those assumptions are not met. To the extent possible, examples are taken from the health services research literature. (Fall)

465. Applied Advanced Multivariate Analysis, Part III
The first part of this course introduces general estimation frameworks including least squares (specifically, least squares as applied to multivariate models and nonlinear least squares), maximum likelihood, generalized method of moments, and some corresponding variants (e.g., quasi-likelihood, Monte Carlo methods, and instrumental variables). The second part of the course focuses on the application of the preceding estimation methods to the development and analysis of qualitative and limited dependent variable models (e.g., logit, probit, multinomial/conditional/nested logit, multinomial probit, mixed logit and probit, and censored and truncated data), duration models (e.g., Kaplan-Meier product limit estimator, Cox’s proportional hazard model, and full parametric specifications), and multivariate models (e.g., multivariate regression, sample selection models, and simultaneous equation models). (Spring)

469. Multivariate Models for Epidemiology
The purpose of this course is to provide students with a strong understanding of and experience in the more advanced quantitative methods for the analysis of epidemiologic studies. A more detailed presentation of the analysis issues of confounding and interaction is presented and a complete presentation of most multivariate techniques.

470. Environmental and Occupational Epidemiology
The objective of this course is to provide an overview of environmental issues related to public health. Physical, social, and psychological environmental issues are addressed through readings, lectures, and discussions as well as field trips and site visits. Selected environmental issues are addressed from the perspective of impact on public health (history and current public health). (Spring)

472. Measurement and Evaluation of Research Instruments
The purpose of this course is to provide students with a comprehensive background in the development and testing of self-report research instruments for epidemiologic research purposes. A review of the principles of survey development begins the course; however, it rapidly moves to a more hands-on approach as students learn how to run and interpret classical test theory analyses, factor analyses, and responsiveness to change analyses. Students learn how to use and integrate these statistical approaches to develop self-report instruments with high levels of validity and low levels of measurement error. (Spring)

476. RCTRC Seminar Series
A weekly seminar series for Rochester Clinical Translational Research Curriculum participants. This series includes presentations from University of Rochester training mentors, guest lecturers, experts in technological innovations in clinical research, as well as trainee presentations.
478. Workshop in Scientific Communication
A noncredit course required of all Rochester Clinical Translational Research Curriculum trainees, Ph.D., and postdoctoral fellows. This workshop series addresses the principal elements of scientific presentation and communication such as medical writing, abstract preparation, poster development, manuscript review and critique, oral presentations, and working with the media/public relations. (Spring)

479. Health, Medicine, and Social Reform
Pursuit of the theme of public health and medical reform in leading writers committed, from different positions along the political spectrum, to the social and economic reorganization of modern society. (Spring, alternate years)

480. Changing Concepts of Disease
Historical account of the way disease has been conceptually understood in the Western tradition. Emphasizes the scientific, epidemiological, philosophical, social, cultural, and professional forces that have shaped the development of ideas. (Spring, alternate years)

483. Advanced Health Economics Part II
The study of how three major parties in the health care system, insurers, hospitals, and physicians, interact and how the nature of these interactions affects the system’s overall economic performance. (Spring)

484. Medical Decisions and Cost-Effectiveness Research
Prerequisite: at least one semester of graduate-level statistics.
Cost-effectiveness research is increasingly used to evaluate alternative choices in clinical practice and to enlighten and inform health policy determinations. In this course, students are introduced to the methods of cost-effectiveness research, including various strategies of evaluating costs and health effects and the ways to present and interpret uncertainty in medical decision making. Students also participate in a lab to learn decision analysis software to conduct cost-effectiveness analyses themselves. (Spring)

488. Experimental Therapeutics
This course is designed for individuals interested in the process for identifying novel interventions for diseases, and for their eventual introduction into humans. Topic areas covered include preclinical laboratory techniques useful in assessing an intervention’s ability to affect fundamental questions regarding the mechanistic effects of chemicals on living organisms.

Our program is among the most established and renowned research-oriented, degree-granting toxicology programs in the nation. Since 1966, graduates from the Toxicology Program at the University of Rochester have been making significant contributions to science through their positions in universities, chemical and pharmaceutical companies, government, and research institutes. It is one of a select few programs funded by the National Institute of Environmental Health Sciences (NIEHS) and is augmented by an NIEHS Center of Excellence. The presence of this center and the strength of the associated faculty offer a unique opportunity for students to learn the theory and techniques of modern research approaches while applying them to address real and significant issues in toxicology from the molecule to the whole organism. In general, about 30–40 students are in residence.

The major disciplinary areas within toxicology at Rochester are the following. It should be recognized that there is a great deal of overlap among these categories.

Neurotoxicology. Chemicals acting on the nervous system, either directly or indirectly, are studied in many different species by a variety of techniques. For instance, recent experiments have studied indices of behavior, motor activity, discriminative control and learning, and neuroimmune interactions, as well as effects on neurotransmitters and their receptors. Nanoparticles, heavy metals, organic solvents, nerve poisons, abused drugs, and aversive airborne substances are among the agents that have been studied.

Cardiovascular and pulmonary toxicology. Physiological and biochemical studies of the lung and vascular system are made in order to discover how inhaled particles and chemicals cause injury. Mechanisms of deposition and clearance of inhaled particles are studied in both laboratory animals and humans. Cellular and molecular aspects of chronic lung injury (e.g., pulmonary
fibrosis, chronic obstructive pulmonary disease, asthma, as well as various immunological aspects) are investigated in animals and extrapolation models then developed in order to predict effects in humans and, perhaps, develop protective measures.

Musculoskeletal toxicology. Investigations are conducted of the molecular and cellular biology of the skeletal system and its development. Ongoing research includes studies to understand the cellular and molecular mechanisms by which exposure to various pollutants, lipid mediators, and novel therapeutic agents modify critical processes within bone development and regeneration.

Molecular modifiers of toxicity. Some faculty in this group attempt to identify specific molecular receptors and transporters underlying the selective action of poisons, the location of these proteins within the cell, and the role of receptor occupancy in order to explain both tissue selectivity and the comparative toxicity of the agent. Currently under investigation are the 2,3,7,8-tetrachlorodibenzop-dioxin (TCDD) receptors and several membrane transport proteins. Other faculty are studying DNA-repair mechanisms, bioactivation processes, the role of glutathione and biotransformation in the defense against toxicants, the role of heme oxygenase in cellular regulation, cell signaling, and the molecular mechanisms underlying metal ion toxicity.

Carcinogenesis. Several of the faculty are investigating the mechanisms of carcinogenesis; the molecular mechanisms of prostate cancer progression; the mechanisms of radiation sensitivity in solid tumors; the control of malignant lymphoma cells; and the growth factors in the normal and abnormal regulation of cell growth and metabolism.

Immunotoxicology. The faculty are focused on how the immune system is involved in both tissue injury and repair as well as the effects of a wide variety of environmental chemicals on immune system functions. Research includes the study of how various exposures alter host responses to infection, leukocyte development, and the regulation of antibody-producing lymphocytes by prostaglandins. Other research examines how exogenous factors, including oxygen and other inhaled agents, aryl hydrocarbon receptor ligands and lipid mediators of inflammation contribute to the ontogeny or severity of immune-mediated diseases such as asthma and autoimmune diseases.

Developmental basis of disease. It is now appreciated that early life exposures (in utero or shortly after birth) have a profound impact on a broad range of diseases, and that the detrimental action of these exposures is often not appreciated for many years. Research in this area focuses on a range problems associated with placental function, developmental immunology, CNS development, growth, teratogenesis, and transplacental carcinogenesis. A particular interest has been establishing the mechanisms of action for metals, pesticides, oxygen and other inhaled agents, aryl hydrocarbon receptor ligands, lipid mediators of inflammation, retinoids, steroids, and drugs used for the treatment of HIV infection during reproduction and development. Research projects also focus on stem cell reprogramming and epigenetic regulatory systems.

The curriculum for predoctoral students provides broad exposure to biochemistry, molecular biology, physiology, pathology, pharmacology, and toxicology. While fulfilling the program’s course requirements during the first year or so, students work on abbreviated research projects in several laboratories. Seminars provide students an opportunity to explore particular areas in greater depth as their interests focus upon specialized research problems. Some seminars are organized on an ad hoc basis when there is a need to explore an area not covered in regular offerings. After the first two years almost all of the student’s time is devoted to laboratory research. Graduate study in the program is intended primarily for students pursuing the PhD.

493. Special Topics in Toxicology—Workplace and Risk Assessment
Credit—two hours
This is a seminar course in which students prepare and present to their peers topics on important workplace substances. Course content includes basic epidemiology of specific diseases or disease categories; practical information on establishing the weight of evidence for an occupational etiology of a specific disease or disease category; review of published literature on epidemiological, toxicology, and industrial hygiene issues addressing specific work place toxins and preparation of presentations that can be understood by a wide variety of audiences. (Fall, even years)

501. Forensic Pathology for Toxicology
Prerequisite: permission of the instructors.
Credit—one hour
This seminar course introduces the discipline of forensic pathology to the toxicologist and examines the application of forensic pathology to criminal and civil investigations. Topics include introduction to systems for the medico-legal investigation of death, conduct of a forensic autopsy, investigation of criminal poisoning, investigation of accidental and suicidal poisoning, investigation of thermal and electrical fatalities, investigation of gunshot and wounds due to explosions, investigation of human and animal abuse, investigation of deaths due to impairment of respiration, the pathophysiology of death, and determination of the time of death. (Fall, even years)

502. Forensic Toxicology
Prerequisite: permission of the instructor.
Credit—one hour
This is a seminar course that examines the application of the physical and biological sciences to criminal investigation. Topics include forensic pathology, forensic chemistry, forensic archeology, forensic anthropology, forensic entomology, forensic toxicology, forensic dentistry, forensic engineering, forensic ballistics, fire and explosion investigations, engineering failures and accidents, and forensic computing. (Fall, odd years)

521. Biochemical Toxicology
Prerequisites: IND 408, PHP 407, and permission of course director.
Credit—four hours
A study of the actions of toxic substances. Prediction of exposures, doses and critical cellular concentrations, adverse effects in
organisms, and responses in populations. Mechanisms leading from reactions with molecular ligands to pathological signs and symptoms are emphasized. This course introduces principles and current theories of biochemical and molecular mechanisms, as they apply to certain organ systems including kidney, immune system, skin, pulmonary system, and nervous system. (Spring)

522. Organ Systems Toxicology  
Prerequisite: TOX 521.  
Credit—four hours

This course continues TOX 521 with a discussion of mechanisms of reproductive toxicology and carcinogenesis. The selective toxicity of certain chemicals is discussed to emphasize dose dependency and mechanisms of action. Finally, current issues and principles applied to the environment, clinical toxicology, modeling, and risk assessment are discussed. (Fall)

530. Reproductive and Developmental Toxicology  
Prerequisite: either medical school pharmacology or PHP 408, or TOX 521.  
Credit—two hours

This course emphasizes the problems associated with infertility, embryonic development, maternal physiology, and postnatal growth following exposure to environmental and therapeutic agents. (Spring, even years)

533. Neurotoxicology  
Credit—one hour

This is a special topics course where subjects are presented and discussed in depth. For example: environmental risk factors for neurodegeneration, developing nervous system as a target for neurotoxicity, glia as targets for neurotoxicity. (Spring, even years)

558. Seminar in Toxicology  
Credit—one hour

Seminars by students examine critically the published research on selected problems in toxicology. Required of toxicology doctoral candidates. (Spring)

564. Pulmonary Toxicology  
Credit—one hour

A specialty seminar that requires presentations from recent literature considering the effects of lung-directed toxic agents on pulmonary anatomy, physiology, and biochemistry. (Fall, odd years)

592. Immunotoxicology  
Credit—one hour

Selected topics relevant to current issues and problems in immunotoxicology and immunopharmacology are covered. The course director provides an overview of this field of study in a brief series of lectures. The students then identify and lead discussion on scientific papers of their choosing. The course draws on recent peer-reviewed publications and/or reviews that are discussed and critiqued by the participants in a journal club-style format. (Spring, odd years)

594. Gene Environment Interactions  
Credit—one hour

The broad aims of this course are to understand how genes and environment interact and influence human health and disease, with a specific focus on pulmonary and neuronal diseases. The course format involves reading current scientific literature with an emphasis on understanding techniques/methods that provide insight into mechanisms underlying complex genetic and environmental interactions that influence human health. In this journal-club style course, the course directors provide an overview of this field of study and lead discussion on one scientific paper. The students then identify and lead discussion on scientific papers of their choosing that have been approved by course directors. (Fall, even years)

595. PhD Research in Toxicology  
Credit to be arranged
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  Assistant Professor Emeritus of Nursing  
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Katharine Hiltunen, MBA, RN (Rochester)  
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Tommye Hinton, MSN, RN, CPHQ, NEA-BC (Wayne State)  
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Patrick Hopkins, DNP, RN, PNP, NNP (Rochester)  
  Assistant Professor of Clinical Nursing  
Elise Kayson, MS, RN, ANP (Rochester)  
  Assistant Professor of Clinical Nursing  
Janet Kemp, PhD, RN (Colorado Health Science)  
  Assistant Professor of Clinical Nursing  
Christina Koulouglioti, PhD, RN (Rochester)  
  Assistant Professor of Nursing  
Elizabeth LeCuyer, PhD, RN, PMHNP-BS (Oregon Health & Science)  
  Assistant Professor of Nursing  
Sharon Lessard, PhD, RN, CS (Austin, Texas)  
  Assistant Professor of Clinical Nursing  
Dianne Liebel, PhD, RN (Rochester)  
  Assistant Professor of Nursing  
Maria Marconi, MS, RN (Georgetown)  
  Assistant Professor of Clinical Nursing  
Daniel Nowak, MS, RN (Rochester)  
  Assistant Professor of Clinical Nursing  
Irena Pesis-Katz, PhD (Rochester)  
  Assistant Professor of Nursing  
Cathy Peters, MS, RN, ANP, NPP (Rochester)  
  Assistant Professor of Clinical Nursing  
Karen Reifenstein, PhD, RN  
  Assistant Professor of Clinical Nursing  
Michelle Roach, MS, RN, PNP (Rochester)  
  Assistant Professor of Clinical Nursing  
Janice Rogers, MS, RN, CS, CPNP-AC (Rochester)  
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William Russell, MS, RN (Rochester)  
  Assistant Professor of Clinical Nursing  
Carolyn Sammann, PhD, RN (Rochester)  
  Assistant Professor of Clinical Nursing  
Barbara Selvek, MS, RN, CCRN (Syracuse)  
  Assistant Professor of Clinical Nursing  
Renuka Singh, MS (RIT)  
  Assistant Professor of Clinical Nursing  
Elizabeth Slavinskas, MS, RN (SUNY, Buffalo)  
  Assistant Professor of Clinical Nursing  
Bonnie Strollo, MS, RN, NPP (Rochester)  
  Assistant Professor of Clinical Nursing  
Sharon Stone, MS, RN, ANP (Boston College)  
  Assistant Professor of Clinical Nursing  
Anne Swantz, MS, RN, PNP (D’Youville)  
  Assistant Professor of Clinical Nursing  
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  Assistant Professor of Clinical Nursing  
Elizabeth Walker, PhD, RN (Rochester)  
  Assistant Professor of Clinical Nursing  
Grace Wlasowicz, PhD, RN (Rochester)  
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Ying Xue, DNSc, RN (Yale)  
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Pamela Heiple, MS, APRN-BC, NPP (Rochester)  
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Jean Mack-Fogg, MS, RN, C, PNP (Rochester)
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Clint Taft, MS, RN (Rochester)
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Kathee Tyo, MS, RN (Rochester)
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Margaret Holland, PhD, MPH (Rochester)
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Carla Jungquist, PhD, FNP (Rochester)
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Lori Keith, PhD (Memphis)
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Research Associate
Accreditation

All areas of study are approved by and registered with the State Education Department, University of the State of New York, Deputy Commissioner for the Professions, Office of Professions, Albany, New York 12234. (518) 474-3862. The Master's and Doctor of Nursing Practice (DNP) graduate programs are fully accredited by the Commission on Collegiate Nursing Education, One Dupont Circle NW, Suite 530, Washington, D.C. 20036, (202) 887-6791.

PhD and MS-PhD Programs

PhD Program

The PhD program, established in 1978, prepares nurses and members of certain other health professions for leadership positions in teaching, research, clinical practice, and the health care system. In 2006, with the goal of promoting interdisciplinary research, the program changed its name from PhD in Nursing to PhD in Health Practice Research and expanded its admission eligibility beyond nursing to include other master’s-prepared licensed health professionals whose research interests are compatible with those of the faculty.

PhD graduates assume faculty positions, engage in innovative models of care through faculty practice, conduct research for the improvement of health care, and formulate health care policy. These roles require the ability to (1) identify the critical questions related to health, illness, and health care delivery, (2) engage in rigorous research concerning behavior in health and illness and the complex phenomena of health care delivery, and (3) use research findings to advance evidence-based practice. Four components of this doctoral program address the development of these skills: (1) theory development and research methods courses, (2) support (cognate) courses, (3) clinically focused research courses, and (4) the dissertation. Research and teaching assistantship experiences totaling 360 hours are required in addition to the coursework and independent research.

A minimum of 60 semester credits in the four component areas is required. Up to 30 credits may be transferred from a previous master’s program to achieve the 90 credits required for a PhD from the University. Additional courses beyond the required minimum may be necessary, depending on the student’s research topic, specific career goals, and prior preparation. A PhD qualifying examination is given when seven core courses are completed. The dissertation proposal defense completes the qualification process for advancement to candidacy. Proposal defense must be completed at least six months prior to final defense of the dissertation. The PhD is awarded following the successful defense of a written dissertation. Sample program plans are available on request.

PhD Admission Requirements

1. Master of Science degree from an accredited program in a health-related discipline.
2. Current clinical licensure.
3. Cumulative GPA of 3.0 for undergraduate work and 3.5 for graduate work.
4. Completed PhD application.
5. Curriculum vitae.
6. Competitive scores on the Graduate Record Examination (general test only).
7. For international students for whom English is not the primary language or who did not complete their master’s degrees in nursing in an English-speaking country, Test of English as a Foreign Language (TOEFL).
8. Favorable interview with faculty member(s), delineating goals and interests for research and doctoral study.
9. Positive letters of recommendation from at least three academics familiar with the applicant’s intellectual ability, academic achievement, research potential, and professional commitment.
10. Statement of applicant’s goals and interests for doctoral study and an additional sample of writing.
11. Beyond the general requirements, during the admissions process strong consideration is given to the match of student research interests with faculty programs of research.

MS-PhD Dual Degree Programs

For highly motivated students with strong academic promise, seven programs are offered that combine MS degrees in nurse practitioner specialties with the PhD. Graduates will be competent, advanced practice nurses and faculty who conduct clinical research and health services evaluations to improve practice in their chosen specialty areas.

The combined accelerated programs meet all requirements of both the MS and PhD programs in the School of Nursing. Completion of the PhD is accelerated by replacing MS-level research courses with PhD research courses and allowing PhD cognate credit for one course in the master’s program. The program design integrates PhD courses with master’s-level courses from the first semester onward. Students complete all coursework for both degrees in three calendar years, earn the MS degree, and go on to complete the PhD dissertation.

The total number of required MS-PhD program credits varies from 91 to 102 depending on the master’s specialty of choice. Additional courses beyond required minimums may be necessary depending on the student’s research topic, specific career goals, and prior preparation. Samples of specialty-specific combined program plans are available from the School of Nursing, Office of Student Affairs.

Both full-time and part-time study is permitted in the PhD program. MS-PhD students may only apply for a full-time program of study. Students admitted to the full-time PhD program usually require a minimum of three and one-half years to complete the program. Minimum completion time for the MS-PhD combined programs is four and one-half years of full-time study.

MS-PhD Admission Requirements

1. Bachelor of Science degree in nursing from an accredited program
2. RN licensure within the United States or U.S. territory.
3. Master’s degree specialty area identified as part of the admissions process
4. One year of clinical experience in appropriate specialty area prior to admission: Acute Care Nurse Practitioner—medical/surgical experience is required; Care of Children and Families Nurse Practitioner—pediatric experience is preferred; Care of Children and Families/Neonatal Nurse Practitioner—two years of neonatal critical care staff nurse experience is required; Adult or Family Nurse Practitioner—nursing experience is preferred
5. Nursing Cumulative grade point average of 3.0 preferred for undergraduate work
6. Statistics course with grade of “B” or above
7. Completed MS-PhD application
8. Curriculum vitae
9. Typewritten professional statement
10. A sample of scholarly writing
11. Competitive scores on the Graduate Record Examination (general test only)
12. Three positive letters of recommendation that speak to the applicant’s professional and intellectual abilities and achievements, potential as an advanced practice nurse, research potential, and professional commitment. One reference should be from a master’s prepared nurse manager/ supervisor in the clinical setting. Others should be from PhD-prepared academicians.
13. Favorable interviews with two SON faculty members delineating goals and interests for combining a clinical master’s degree with the PhD degree

For International students only: TOEFL scores >88 i-based.

Beyond the general requirements, during the admissions process strong consideration is given to the match of student research interests with faculty programs of research.

Financial Assistance

Full tuition scholarships, up to 60 credits, may be granted to full-time PhD students, and for 60 credits of PhD-level coursework for full-time students in the MS-PhD combined programs depending on availability of funds. Some School of Nursing stipend support may be available for full-time PhD study, again depending on availability of funds. Applicants may be considered for highly competitive University-wide funding if applications are received by February 1. Students who are employees of the Strong Health system may be eligible for tuition benefits. There are opportunities for paid, part-time teaching or research assistantships in the School of Nursing. For those who are eligible, submission of a National Research Service Award application is strongly encouraged. A variety of other external funding sources may be explored through resources in the School of Nursing.

DNP Program

The Doctor of Nursing Practice (DNP) program was established in 2007. This clinical doctorate prepares advanced nurse practitioners to lead the delivery and evaluation of evidence-based, patient-centered care; synthesize research findings to develop and/or refine practice guidelines; and integrate information technology into the management, application, and evaluation of patient care. DNP graduates assume roles in a wide variety of direct and indirect care roles such as direct care clinicians, quality improvement directors, health care administrators, faculty members, political appointees, and policy advocates.

Consistent with the other doctoral programs within the University of Rochester, students in the DNP program are required to complete a minimum of 90 credits as well as a minimum of 1,000 post-baccalaureate clinical hours. Students complete coursework in evidence-based practice and translational research including advanced statistics and epidemiology; leadership, systems management, and strategic planning; health policy, informatics, and interprofessional partnerships. At the completion of the program, students are required to defend an evidence-based capstone project, the practice doctorate’s equivalent to a PhD research dissertation.

Students may enter the DNP program as post-baccalaureate students or post-master’s students. Credits may be transferred from a previous master’s program to achieve the 90 credits required for degree completion. Both full-time and part-time study is permitted. Students admitted to the full-time post-baccalaureate DNP program usually require four years to complete the program. Those admitted to the full-time post-master’s DNP typically complete the program in two years. Sample program plans are available on request.

Admission Criteria

- Bachelor’s or master’s degree in nursing
- RN licensure within the United States or U.S. territory
- Cumulative GPA of 3.0 for undergraduate work and 3.5 for graduate work (preferred)
- Completed DNP application including essay/personal goal statement, writing sample, and curriculum vitae or resume
- Competitive scores on the Graduate Record Examination (general test only) within the past five years or successful completion of an accredited doctoral program
- For international students for whom English is not the primary language or who did not complete their degree in nursing in an English speaking country, Test of English as a Foreign Language (TOEFL; minimum scores required as follows: above 560 (regular paper test) or above 230 (regular computer test) or 88 (new “i-based” test).
- National certification (if available) in advanced nursing practice specialty area
- Favorable interview with at least two faculty members delineating motivation and goals for doctoral study and advanced nursing practice
Four positive letters of recommendation: at least one from an academician, at least one from a supervisor in an employment setting, at least one from a doctorally prepared professional, and at least one from a practicing Registered Nurse. Taken together, these references should speak to the applicant’s intellectual ability, clinical proficiency, academic achievement, and professional commitment.

Financial Assistance
Financial assistance is not generally available through School of Nursing scholarships. Area health care institution reimbursement is the most common form of aid. Additional information on outside opportunities and sources of support is available on the School of Nursing website (www.son.rochester.edu).

Accelerated BS and MS for Registered Nurses
This is an accelerated bachelor and master of science degree program (RN to BS to MS program) for registered nurses whose original educational preparation was received in a diploma or associate degree-granting institution. The program is specifically designed for registered nurses who have identified a nurse practitioner master’s degree as their educational goal and who possess the motivation and potential to complete graduate studies. Up to 96 credits may be transferred from prior coursework (64 arts and sciences credits and 32 nursing credits) to be applied toward the RN to BS to MS program. This may result in the applicant needing to take only three undergraduate bridge courses (12 credits) in addition to the master’s program curriculum. Professional nurses who have an associate’s degree or diploma with a major in nursing, and very strong grades, are eligible to apply for admission to the RN to BS to MS program for part-time study.

Accelerated Master’s Program for Non-Nurses (AMPNN)
This is a program for entry into nursing for second-degree students (non-nurses with a baccalaureate degree in another discipline). Students should have substantial experience in the health care field and very strong grades for this program. The program includes an accelerated generalist baccalaureate degree in nursing to be completed in 12 calendar months of full-time study. Upon successful completion of the generalist curriculum, the BS is awarded and students are eligible for registered nurse licensing examinations (NCLEX). Following completion of the generalist curriculum, students move into one of the MS nurse practitioner specialty programs. These programs can be completed in an additional two years of full-time study. Students choosing the Acute Care specialty need one year of experience as an RN prior to beginning clinical coursework at the master’s level. At the successful completion of the specialist curriculum, students are awarded the MS degree and are eligible for nurse practitioner licensure.

Course descriptions for year-one baccalaureate-level coursework in the AMPNN can be found in the Official Bulletin, Undergraduate Studies (also on the web at www.rochester.edu/Bulletin).

Master’s Programs
The School of Nursing offers Master of Science degrees with a clinical concentration (nurse practitioner programs or clinical nurse leader) or a leadership focus (health care management and leadership or clinical research coordinator). The clinical programs are for nurses who want to expand their skill sets and explore new opportunities as care providers. Graduates assume a variety of roles in hospital, outpatient, and community settings. The leadership program is an interdisciplinary program for both nurses and other health care professionals ready to take their career to the next level and influence health systems.

Nurse Practitioner Master’s Programs and Post-Master’s Programs
Professional nurses who have baccalaureate degrees with a major in nursing are eligible to apply for admission to full- or part-time study in the master’s nurse practitioner programs. There are several areas of concentration in the nurse practitioner programs, which provide an opportunity for depth and breadth of preparation in nursing specialty (population) areas, and for role development as scholar/advanced practitioners and leaders. While each clinical nursing area has its special requirements, there are common substantive areas of study including theory, evidence-based practice, ethics, and public policy. All areas of concentration require completion of from 42 to 61 credits in addition to 560–960 hours of supervised clinical experience for the degree. Students are responsible for planning, in consultation with their faculty advisors, a course of study designed to complete the degree requirements. Continuing study beyond the master’s degree is encouraged, based on individual goals and interests.

Nurse practitioner specialties include: Acute Care Nurse Practitioner (Cardiovascular, Critical Care), Adult Nurse Practitioner, Adult/Geriatric Nurse Practitioner, Care of Children and Families—Pediatric Nurse Practitioner, Care of Children and Families—Neonatal Nurse Practitioner, Family Nurse Practitioner, Gerontological Nurse Practitioner (Post-Master’s only), Psychiatric/Mental Health Nurse Practitioner (Adult/Family), and Psychiatric/Mental Health Nurse Practitioner (Child/Adolescent). The latter two programs are now combined into one Family Psychiatric/Mental Health Nurse Practitioner Program.

Acute Care Nurse Practitioner
The acute care nurse practitioner graduate nursing specialty prepares students for advanced practice positions as nurse practitioners in cardiovascular or critical care. Clinical skills necessary for solving clinical problems, for planning and managing health care for a specialty group of patients, and for identifying and exploring researchable questions are developed. The specialty offers students opportunities to study in a variety of acute and chronic care settings. Critical appraisal of how advanced practice nurses affect patient care delivery and health care practices at the institutional, local, and national level is undertaken. Graduates of the specialty are eligible for New York State and national certification as acute care nurse practitioners.
Care of Children and Families—Pediatric Nurse Practitioner, Pediatric Nurse Practitioner/Neonatal Nurse Practitioner
This specialty prepares advanced practice nurses as pediatric or neonatal nurse practitioners. Students acquire the knowledge, attitudes, and skills necessary to work with healthy children, as well as those affected by acute and chronic diseases and disabilities. Students are prepared to function independently and as part of an interdisciplinary team. Emphasis is placed on identifying the empirical and theoretical bases of pediatric nurse practitioner roles. Case management skills working with individual clients and groups are developed. This specialty is based on an understanding of normal and abnormal physical and psychosocial development and aimed equally at health promotion, maintenance, and restoration. Graduates are eligible for New York State and national certification as pediatric or pediatric/neonatal nurse practitioners.

Adult, Family, and Adult-Geriatric Nurse Practitioner
The graduate specialties in primary care prepare the nurse practitioner student for advanced practice in a variety of health care delivery systems. In community-based clinical settings that provide primary health care, students develop the skills necessary to identify, manage, and refer commonly occurring health problems, to maintain health, and to prevent illness. Graduates of these specialties are eligible for New York State and national certification as adult, family, or adult-geriatric nurse practitioners and are uniquely prepared to provide primary care to populations across the lifespan with unmet needs, particularly the socially and economically impoverished and underserved, and the chronically ill.

Family Psychiatric/Mental Health Nurse Practitioner
This specialty is designed to prepare advanced practice nurses who are competent to provide care and assume leadership roles in the care of patients with psychiatric/mental health needs. Graduates are eligible for New York State and national certification as psychiatric/mental health nurse practitioners when graduation requirements are met.

Admission Requirements for Nurse Practitioner Master’s Programs
An introductory course in statistics is prerequisite for admission to all master’s programs. Applicants (except to AMPNN) must give evidence of the fulfillment of legal requirements for the practice of nursing in some state in the United States or its territories. Personal interviews with faculty members may be required as part of the admission process. These interviews may be conducted by telephone if necessary.

All applicants for admission must submit the following to the Office of Admissions, School of Nursing:

- a completed application for admission
- a professional statement, résumé/CV, and writing sample (AMPNN requires only the statement and résumé/CV)
- two favorable references which address professional and/or academic ability
- official transcripts of all previous college-level academic work and evidence of cumulative 3.0 GPA preferred.

Once accepted for admission, all prospective students MUST comply with University and New York State immunization requirements prior to beginning coursework. Students are responsible for providing annual verification of immunization updates. A current license to practice nursing must be on file with the School of Nursing (except AMPNN in year one), where licensure as a registered nurse is required for clinical coursework.

Master of Science—Leadership in Health Care Systems
The Leadership Program is an interprofessional platform intended to prepare nurses and non-nurses for the challenges of managing and leading health systems in the 21st century. The Leadership Program is part time, with graduates earning an MS in Leadership in Health Care Systems in 16–18 months.

Students take a core group of courses in leadership and select from one of three concentrations: (1) Health Management and Leadership; (2) Clinical Research Coordination; (3) Clinical Nurse Leader (CNL—open to RNs only). Thirty (30) to 37 credits of academic coursework are needed for graduation, depending on the program.

Modeled after executive business programs, the core didactic content reflects competencies essential for health care leaders in the twenty-first century. The content in the three concentrations reflects specialty knowledge and competencies. Progression through the program builds a foundation for the final leadership capstone project. For this, students are placed with a health care executive to experience real world issues, refine their leadership skills, and complete a capstone project.

Admission Requirements for MS in Leadership in Health Care Systems Programs
1. Completion of a Bachelor of Science degree from an accredited college or university. For CNL, degree must be in nursing from an accredited school. CNL applicants also need current RN licensure within the United States or a U.S. territory.
2. Cumulative GPA of 3.0 preferred on a 4.0 scale from a bachelor’s degree program.
3. Statistics course with a grade of C or above.
4. Professional statement.
5. Two favorable references that address professional and/or academic ability, and leadership ability. It is desirable that one of the letters be from a professional in health care. CNL applicants’ letters of reference (one from an immediate supervisor) should address clinical expertise and leadership talent.
6. Personal interview(s) with LHCS program faculty members.
7. Additional CNL requirements—Clinical practice exemplar relating to patient care (which describes what happened, the intent and the outcomes of actions and interactions with other members of the health care team), and a minimum of three years of employment as a registered nurse in a clinical setting.

Graduate Program Curricula
Specific course and clinical requirements for each specialty can be found on the web: www.son.rochester.edu/programs/index.html.
The School of Nursing reserves the right to cancel courses with insufficient enrollment. Curriculum revision at the graduate level is continuous and courses may be modified.

CORE AND CLINICAL CORE COURSES

400. Research Principles for Evidence-Based Advanced Practice
Credit—five hours

This course is designed to prepare advanced practice nurses in applying evidence to practice and using evidence to drive clinical decision making. Students learn the foundations of research methods that underlie evidence-based practice. The course focuses on developing clinical questions, analyzing clinical data, evaluating pertinent research, and developing practice recommendations. Students explore outcomes in the contexts of professional practice and population management. Students gain a greater appreciation of how theory and practice articulate and how best to apply theory to a clinical problem.

401. The Writing Workshop
Credit—one hour

The purpose of this course is to help students gain proficiency in writing. It provides graduate students with the essential tools for scholarly writing. Rules of grammar, punctuation, format, and composition are reviewed and practiced. Styles of composition are analyzed and applied in writing exercises. The importance of focused presentation of ideas, and clarity and progression of thought are emphasized.

403. Ethics and Public Policy in the Health Care System
Credit—three hours

This foundational course provides an overview of the structure, regulation, and financing of the health care system in the United States. Nursing’s past and present contributions and its potential to shape future health care are evaluated. Contemporary health care and policy issues are examined using concepts and principles of planned change, ethical decision making, the policy process, and policy analysis.

407A. Physiological and Pathophysiological Basis of Advanced Nursing Practice
Prerequisite: undergraduate anatomy and physiology.
Credit—one to five hours

A study of those physiologic processes that are a basis for advanced nursing practice. The focus is on regulatory mechanisms that maintain homeostasis. Content is based on theories from physiologic and immunologic research. This course is offered with varying credit and consists of: Unit I, cell physiology and immunology; Unit II, neurophysiology and endocrinology; Unit III, cardiovascular and respiratory physiology; and Unit IV, renal and gastrointestinal physiology.

410. Advanced Health Assessment
Prerequisite: prior health assessment coursework or refresher.
Credit—four or six hours (two of which are lab)

This graduate-level course provides the theoretical and clinical foundation for advanced comprehensive assessment of the health status of individuals and families. Building on undergraduate preparation, principles of complex interviewing, and history taking; diagnostic reasoning; and advanced physical, psychosocial, cultural, developmental, and environmental assessments are presented. From a functional and developmental base, the course emphasizes techniques for discrimination and analysis of common abnormal findings, the process of differential diagnosis, and methods for presentation of findings. Theoretical contexts of health promotion are discussed and applied to clinical findings. This course includes laboratory modules for specialty skill instruction.

411. Evaluation and Management of Common Adult Health Care Problems
Prerequisites: NUR 407A, 410, 419; Pre- or corequisite NUR 400.
Credit—five hours (three didactic, two clinical)

This course focuses on the evaluation and management of manifestations of common health deviations across the adult lifespan in a variety of settings and across cultures. Biopsychosocial and pharmacological concepts are applied in formulating differential diagnoses and management plans. Emphasis is placed on developing the advanced practice role in the context of a comprehensive, interdisciplinary approach. This course builds on the advanced assessment concepts and skills in the synthesis of assessment data in order to develop a comprehensive plan of care including appropriate follow-up.

412. Advanced Pediatric Health Assessment and Care of Well Children and Adolescents
Prerequisite: prior health assessment coursework or refresher.
Credit—five hours (three didactic, two clinical)

This graduate-level course provides the theoretical and clinical foundation for advanced comprehensive pediatric health assessment. Students develop the necessary expertise to provide primary health care to well children and adolescents. Students gain experience interviewing pediatric clients and their families and providing relevant anticipatory guidance, using age-appropriate techniques. Students engage in health teaching regarding common pediatric health care concerns, including the provision of nutritional and breastfeeding advice, immunization guidance, promotion of healthy habits, safety promotion and injury prevention, and the management of common child behavioral issues. Course content supports students’ clinical experience in the provision of primary health care to well infants, children, adolescents, and their families.

413. Family Theoretical Frameworks and Application to Nursing Care of Families
Credit—three hours

Required of all Family Nurse Practitioner students, this course examines theoretical frameworks relevant to family nursing interventions. The family in health and illness and the impact of transitions, crises, and stressful events on families are explored. Clinical situations with families are examined and analyzed in light of theory and concepts. Students examine their own beliefs and family life experiences as these relate to family nursing.
419. Advanced Pharmacology
Prerequisites: introductory human physiology and pharmacology. Unit I prerequisite to Unit II.
Credit—three hours
This is an advanced course in pharmacology that includes Unit I—one credit of online course material including interpretation of New York State and federal laws and regulations pertaining to prescribing drugs and record keeping; and Unit II—two credits of pharmacokinetics, pharmacotherapeutics, and clinical decision making in drug management for the advanced practice of nursing.

492. Advanced Clinical Practicum
Credit—variable

493. Comprehensive Examination
Credit—none
A comprehensive examination is required for all master’s students. Successful completion of a comprehensive examination demonstrates students’ abilities to integrate knowledge gained through individual courses into critical thinking and advanced practice. Students enroll and complete the exam during the last semester of their academic coursework.

CLINICAL SPECIALTY COURSES

Acute Care Nurse Practitioner
424. Acute Care Nurse Practitioner I
Prerequisites: NUR 403, 411.
Credit—seven hours (three didactic, four clinical)
This course is the first in a two-course specialty sequence for Acute Care Nurse Practitioner students. It is designed to build on the concepts of advanced health assessment and the diagnosis and management of common problems in adults. Emphasis is placed on content-specific to the specialty areas of critical care, cardiovascular care. Content addressing theory and research is presented that (1) crosses areas of specialization, and (2) is focused within each of the two specialty populations (critical care and cardiovascular). Case examples and clinical experiences are provided that allow students to become increasingly independent in their own clinical practice with respect to critical thinking and problem solving. Emphasis in role development is placed on effecting change and integration of the multiple roles for advanced practice nurses in an interdisciplinary, integrated health system.

425. Acute Care Nurse Practitioner II
Prerequisites: NUR 424.
Credit—10 hours (four didactic, six clinical)
This course is the second in a two-course sequence for ACNP students. It is designed to prepare students for advanced practice in the care of acutely ill specialty patients and their families. The course builds on the content from ACNP I. Emphasis is placed on the development of both direct patient care and systems support components of the advanced practice role. A major focus is on the development of leadership abilities within health care systems and interdisciplinary teams. Critical appraisal of how advanced practice nurses affect patient care delivery and health care practices at the institutional, local, and national level is undertaken. Content addressing theory and research is presented that (1) crosses areas of specialization, and (2) is focused within each of the two specialty populations (critical care and cardiovascular). Case examples and clinical experiences are provided that allow students to become increasingly independent in their own clinical practice with respect to critical thinking and problem solving. Emphasis in role development is placed on effecting change and integration of the multiple roles for advanced practice nurses in an interdisciplinary, integrated health system.

Care of Children and Families
430. Advanced Practicum in the Care of the High-Risk Neonate
Prerequisites: NUR 407A, 412, 419, 436.
Credit—three hours clinical practicum
Required practicum for those enrolled in the Care of Children and Families: Pediatric Nurse Practitioner/Neonatal Nurse Practitioner specialty.

431. Advanced Practicum in the Care of the High-Risk Neonate II
Prerequisite: NUR 430.
Credit—three hours clinical practicum
Required practicum for those enrolled in the Care of Children and Families: Pediatric Nurse Practitioner/Neonatal Nurse Practitioner specialty.

432. Care of the Neonate and Infants I
Credit—one to three hours
(Required for post-master’s NNP)

433. Care of the Neonate and Infants II
Credit—one to five hours
(Required for post-master’s NNP)

435. Advanced Concepts in Child and Adolescent Development
Prerequisite: undergraduate course in human development.
Credit—three hours
This is an advanced course in child and adolescent development for those individuals who desire to gain greater knowledge and depth in the complex issues surrounding human development. Major theories of child development provide a framework for the presentation of physical, cognitive, social, and emotional development from conception through adolescence. Factors influencing growth and development are highlighted. Discussions of classic and current studies as they relate to human development are integrated throughout the course. Emphasis is placed on developmental assessment and intervention for health care providers. Course content also includes management strategies for common behavioral problems encountered at various stages of development.

436. Nursing Care of the High-Risk Neonate
Prerequisites: NUR 407A, 412, or permission of instructor.
Credit—three hours
This course provides didactic content in the nursing care of high-risk neonates. Course emphases are on assessment and
The focus in this area of emphasis is on developing skills for case management from both a community and population perspective, reimbursement structures, interdisciplinary team building, and on further development of leadership and health care management in health care systems. The course has two major emphases. The first is for students focusing on families within the context of a culturally diverse society and complex health, social, and/or behavioral problems; and their families. Nursing, developmental, family systems, role, organizational, leadership, and other theoretical frameworks are used to examine the impact of complex health problems on children, families, and society. Students also use these foundations to build abilities to plan, implement, and evaluate strategies and programs for promoting optimal outcomes for children and families experiencing acute or chronic illness or disability.

This is the second in a sequence of three clinical courses designed to prepare students for leadership roles in the advanced nursing care of children and families within a culturally diverse society. The course has two major emphases: beginning development of leadership and health management skills, and development of competency in assessment and intervention strategies for children experiencing increasingly complex health, social, and/or behavioral problems; and their families. Nursing, developmental, family systems, role, organizational, leadership, and other theoretical frameworks are used to examine the impact of complex health problems on children, families, and society. Students also use these foundations to build abilities to plan, implement, and evaluate strategies and programs for promoting optimal outcomes for children and families experiencing acute or chronic illness or disability.

This is the third in a sequence of three clinical courses designed to prepare students for leadership roles in the advanced nursing care of children and families within a culturally diverse society. The second emphasis is on development of competency in advanced nursing practice with children and adolescents who are experiencing the most complex health conditions, and their families.

Clinical Specialty Courses

437. Leadership in Advanced Nursing Care of Children and Families: Advanced Concepts in Pediatric Primary Care
Prerequisites: NUR 412, 407A for CCF students; NUR 410, 407A for FNP students. Pre- or corequisites: NUR 400, 403.
Credit—seven hours for PNP students (two clinical), four hours for FNP students

This is the first in a sequence of three clinical courses designed to prepare students for leadership roles in the advanced nursing care of children and families within a culturally diverse society. Emphasis is placed on assessment and management strategies with children and adolescents who are well or who are experiencing minor health problems commonly encountered in primary care settings. Course content is guided by a variety of theoretical and empirical perspectives relevant to clinical practice. Students develop physical and psychosocial assessment and intervention skills specific to the pediatric population, using a diagnostic reasoning process. Clinical practice sites include a variety of primary care settings.

438. Advanced Nursing Care of Children and Families II: Management of Complex Health Problems
Prerequisites: NUR 419, 437, and for students in the neonatal track, NUR 436.
Credit—six hours (three didactic, three clinical)

This is the second of three clinical courses designed to prepare students for advanced nursing care of children and families within a culturally diverse society. The course has two major emphases: beginning development of leadership and health management skills, and development of competency in assessment and intervention strategies for children experiencing increasingly complex health, social, and/or behavioral problems; and their families. Nursing, developmental, family systems, role, organizational, leadership, and other theoretical frameworks are used to examine the impact of complex health problems on children, families, and society. Students also use these foundations to build abilities to plan, implement, and evaluate strategies and programs for promoting optimal outcomes for children and families experiencing acute or chronic illness or disability.

439. Advanced Nursing Care of Children and Families III: Leadership in Complex Organizations
Prerequisites: NUR 438.
Credit—seven hours (three didactic, four clinical)

This is the third of three clinical courses designed to prepare students for leadership roles in the advanced nursing care of children and families within the context of a culturally diverse society and complex health care systems. The course has two major emphases. The first is on further development of leadership and health care management skills, with special emphasis on integrated delivery systems, managed care, reimbursement structures, interdisciplinary team building, and case management from both a community and population perspective. The focus in this area of emphasis is on developing skills for independence in indirect care, and on overcoming systems barriers as a change agent in health care for children and their families. The second emphasis is on development of competency in advanced nursing practice with children and adolescents who are experiencing the most complex health conditions, and their families.

Adult Nurse Practitioner, Family Nurse Practitioner, and Adult-Gerontological Nurse Practitioner

444. Primary Health Care I
Prerequisites: NUR 411, 413 (pre- or corequisite for FNP students); pre- or corequisite NUR 403.
Credit—six hours (two didactic, four clinical)

Clinical experience, seminars, topical discussions, and case examples provide an opportunity for synthesis and integration in all aspects of primary care nursing. New content relating to the natural history of health and disease within families over time is included. Students broaden their perspective of the health care provider role in developing the competence and confidence of professional colleague, advanced clinician, consultant, and leader. Providing primary health care to a specific consumer population over an extended period allows the student to assume and share responsibility and accountability in dealing with broad ongoing health care needs as they occur in the family environment.

445. Primary Health Care II
Prerequisite: NUR 444.
Credit—seven hours (two didactic, one role, four clinical)

This course is a continuation of NUR 444, with seminars, clinical topic discussions, case examples, and clinical practice. Special emphasis is placed on leadership, teaching, and research in the larger community, and on the evaluation of health care services. Emphasis in role development is placed on effecting change and integration of the multiple roles for advanced practice nurses in an interdisciplinary, integrated health system.

447. Interdisciplinary Care of the Older Adult
Prerequisite: NUR 403; pre- or corequisite NUR 411.
Credit—five hours (three didactic, two clinical)

The focus of the course is on interdisciplinary care of older adults across the health care continuum. The unique dynamics of geriatric care are explored within the context of the normal aging process. The course includes psychological and sociological, cultural, and developmental issues of older adults. The unique challenges of aging, including financial challenges, are explored. Foundational information necessary for the identification of health needs of older adults is considered. Best practice initiatives are applied in the clinical setting.

448. Evaluation and Care of the Older Adult
Prerequisite: NUR 403; pre- or corequisite NUR 411.
Credit—six hours (four didactic and two clinical)

The focus of this course is on health (including mental health) issues of older adults with emphasis on presentation of illness, diagnostic testing, differential diagnosis, and formulation of a comprehensive management plan. The biopsychosocial model is
used as a framework to discuss geriatric syndromes and complex, chronic illness in older adults. Appropriate gero-pharmacological and non-pharmacological treatment options (including procedures) are explored. Approaches for comprehensive assessment and evidence-based treatments are highlighted.

449. Women’s Health Care for Primary Care Generalists
Prerequisite: NUR 411.
Credit—three hours (one didactic, two clinical)
This course is designed to prepare primary care students for advanced practice in the reproductive health care of women. The course focuses on the management of the most commonly encountered obstetric and gynecologic health care needs for the healthy woman throughout her adolescent and adult years, with the explicit understanding that the woman is an active partner in her own care. The course emphasizes consideration of each woman’s health within the unique context of her physical, interpersonal, and sociocultural environments and encourages analysis of resources and deficits for health from both the individual and health systems perspective. Critical synthesis of research for application to practice is stressed.

Psychiatric/Mental Health Nursing
450. Psychopathology, Psychiatric Diagnosis, and Assessment across the Lifespan
Prerequisite: NUR 452.
Credit—five hours
This is a foundational course that provides the graduate student with a biopsychosocial framework for the practice of psychiatric mental health nursing. Students develop advanced knowledge of current theories related to the etiology and classification of adult personality development and psychopathology. Personality development is conceptualized as an evolutionary lifespan process arising from the continual interaction of person with environment. Personality patterns are depicted along a continuum ranging from adaptive to maladaptive, and are identified and explored through case examples. Students are able to apply psychological and physical assessment knowledge and skills to determine functional and/or organic causes of alteration in biopsychosocial functioning. They begin to develop a perspective of the role of the advanced practice nurse and develop the initial skills required for this role.

451. Individual Psychotherapy across the Lifespan
Pre- or corequisites: NUR 450, 455.
Credit—four hours
This course is a systematic exploration of the theory and evidence-based practice of providing psychotherapy for specific disorders and age groups across the lifespan. This course builds upon the students’ knowledge of psychosocial development, mental health assessment, and psychopathology. Therapy models, derived from various theoretical frameworks, are applied to case examples. The process of the psychotherapeutic relationship is examined. Attention is given to the cultural, ethical, legal, and public policy implications of providing psychotherapy for individuals of various ages and cultural backgrounds. This course is taught primarily online.

452. Pathophysiology of Mental Illness and Psychopharmacology across the Lifespan I
Prerequisites: NUR 407A, 419.
Credit—three hours
Pathophysiology of Mental Illness and Psychopharmacology across the Lifespan I offers an in-depth investigation of the neurobiological basis of major psychiatric illnesses for individuals across the lifespan. This foundational course is the first of two courses that allows the student to apply knowledge of pathophysiology, pharmacokinetics, and pharmacodynamics to design, analyze, and evaluate pharmacological treatment regimes informed by research evidence and best practice guidelines. Content in this course focuses on common mental health issues across the lifespan (e.g., autism, attention deficit hyperactivity disorder, anxiety, and mood disorders). This course is taught primarily online.

453. Pathophysiology of Mental Illness and Psychopharmacology across the Lifespan II
Prerequisite: NUR 452.
Credit—three hours
Pathophysiology of Mental Illness and Psychopharmacology across the Lifespan II offers an in-depth investigation of the neurobiological basis of major psychiatric illnesses for individuals across the lifespan. This is the second of two courses that allows the student to apply knowledge of pathophysiology, pharmacokinetics, and pharmacodynamics to design, analyze, and evaluate pharmacological treatment regimes informed by research evidence and best practice guidelines. Content in this course focuses on more complex mental health issues across the lifespan (e.g., thought disorders, substance abuse, and impulse control disorders). This course is taught primarily online.

454. Group and Family Psychotherapy for the Psychiatric Mental Health Nurse Practitioner
Prerequisites: NUR 450, 451.
Credit—three hours
This course provides the theoretical basis for the understanding and implementation of group and family psychotherapy. Consumers include the family as client as well as the group and/or family as the context of care for the individual client. Students develop an advanced knowledge of current theories and practice modalities related to the practice of group and family psychotherapy and develop the skills required of a psychiatric nurse practitioner.

455. Theoretical Frameworks of Advanced Psychiatric/Mental Health Nursing Practice
Credit—three hours
This is a foundational course that introduces students to theoretical frameworks that are applied throughout their graduate
456. Practicum in Psychiatric/Mental Health Nurse Practitioner Role I
Prerequisites: NUR 410, 450.
Credit—three clinical hours

This course provides students with a forum to synthesize knowledge acquired throughout the curriculum and facilitates role and skill development for advanced family psychiatric mental health nursing practice with individuals across the lifespan and their families from diverse cultures. The purpose of this practicum is to equip students with the skills to enact the role of the nurse practitioner through the integration of knowledge acquired throughout the curriculum and facilitates role and skill development for advanced FPMH nursing practice with individuals across the lifespan and their families. Students build on prior life span competencies to include applying family, systems, and organizational theories in facilitating team processes. Students identify opportunities for interdisciplinary collaboration, referral, and consultation, recognizing system issues, and identifying influences of organizational culture on quality of care. Students integrate legal and ethical considerations in clinical decision making. Students explore the influence of public policy and develop plans for advocating for organizational and system change to promote quality outcomes within a continuum of mental health services. The seminar format facilitates the integration of theory with precepted clinical practice. Case presentations and role-plays are utilized as integral components of seminar discussions. Students incorporate evidenced-based resources in evaluating clinical performance and case presentations.

457. Practicum in Psychiatric/Mental Health Nurse Practitioner Role II
Prerequisite: NUR 456.
Credit—four clinical hours

This course provides students with a forum to synthesize knowledge acquired throughout the curriculum and facilitates role and skill development for advanced FPMH nursing practice with individuals across the lifespan and their families. Students build on prior knowledge while using current evidence to apply psychotherapeutic modalities and psychopharmacology in comprehensive treatment planning for individuals across the lifespan. Students provide client and family psychoeducation regarding evidence-based treatments and partner with clients and families in treatment planning with sensitivity to cultural issues. Students integrate legal and ethical considerations in clinical decision making. Clinical practicum seminars facilitate the integration of theory with precepted clinical practice. Case presentations and role-plays are utilized as integral components of seminar discussions. Students incorporate evidenced-based resources in evaluating clinical performance and case presentations.

458. Practicum in Psychiatric/Mental Health Nurse Practitioner Role III
Prerequisite: NUR 457.
Credit—four clinical hours

This course provides students with a forum to synthesize knowledge acquired throughout the curriculum and facilitates role and skill development for advanced FPMH nursing practice for individuals across the lifespan and their families. Students build on prior life span competencies to include applying family, systems, and organizational theories in facilitating team processes. Students identify opportunities for interdisciplinary collaboration, referral, and consultation, recognizing system issues, and identifying influences of organizational culture on quality of care. Students integrate legal and ethical considerations in clinical decision making. Students explore the influence of public policy and develop plans for advocating for organizational and system change to promote quality outcomes within a continuum of mental health services. The seminar format facilitates the integration of theory with precepted clinical practice. Case presentations and role-plays are utilized as integral components of seminar discussions. Students incorporate evidenced-based resources in evaluating clinical performance and case presentation.

460. Practicum in Advanced Adult/Family Psychiatric/Mental Health Nurse Practitioner Role I
Prerequisites: NUR 410 or 412, pre- or corequisite NUR 470.
Credit—three clinical hours

This course provides students with a forum to synthesize knowledge acquired in didactic courses and facilitates role and skill development for advanced psychiatric mental health nursing practice with adults and their families. Students apply knowledge of psychopathologies, differentiating normal from abnormal development and psychosocial functioning in adults. Culturally sensitive approaches and knowledge of cultural diversity are applied in processes of assessment, differential diagnosis, psychoeducation, and beginning treatment planning. Students recognize and intervene with clients and families with or at risk for common psychiatric emergencies, preserving their dignity and confidentiality. The importance of understanding one’s emotional responses to others is applied to processes of therapeutic relationship development. Clinical practicum seminars facilitate the integration of theory with precepted clinical practice. Case presentations and role-plays are utilized as integral components of seminar discussions. Students incorporate evidenced-based resources in evaluating clinical performance and case presentations.

461. Practicum in Advanced Adult/Family Psychiatric/Mental Health Nurse Practitioner Role II
Prerequisites: NUR 460, 471, 477; pre- or corequisite NUR 463.
Credit—four hours

This course provides students with a forum to synthesize knowledge acquired throughout the curriculum and facilitates role and skill development for advanced psychiatric mental health nursing practice with adults and their families. Students build
on prior competencies while applying knowledge of psychotherapeutic modalities and psychopharmacology in comprehensive treatment planning for adult clients. Students recommend therapy models and psychopharmacological agents based on current evidence and practice guidelines. Students provide client and family psychoeducation regarding evidence-based treatments and partner with clients and families in treatment planning with sensitivity to cultural issues. Students integrate legal and ethical considerations in clinical decision making. Clinical practicum seminars facilitate the integration of theory with precepted clinical practice. Case presentations and role-plays are utilized as integral components of seminar discussions. Students incorporate evidence-based resources in evaluating clinical performance and case presentations.

462. Practicum in Advanced Adult/Family Psychiatric/Mental Health Nurse Practitioner Role III
Prerequisite: NUR 461.
Credit—four clinical hours
This course provides students with a forum to synthesize knowledge acquired throughout the curriculum and facilitates role and skill development for advanced psychiatric mental health nursing practice with adults and their families. Students build on prior competencies to include applying family, systems, and organizational theories in facilitating team processes; identifying opportunities for interdisciplinary collaboration, referral, and consultation; recognizing system issues; and identifying influences of organizational culture on quality of care. Students integrate legal and ethical considerations in clinical decision making. Students explore the influence of public policy and develop plans for advocating for organizational and system change to promote quality outcomes within a continuum of mental health services. Clinical practicum seminars facilitate the integration of theory with precepted clinical practice. Case presentations and role-plays are utilized as integral components of seminar discussions. Students incorporate evidence-based resources in evaluating clinical performance and case presentations.

470. Theories of Psychotherapy, Psychopathology, and Mental Health
Pre- or corequisite: NUR 475.
Credit—three hours
This is a foundational course that provides the graduate student with a biopsychosocial/spiritual framework for the advanced practice of psychiatric mental health nursing. Students develop a perspective of the advanced practice role, with emphasis on psychiatric assessment, diagnosis, and evaluation. Selected theoretical frameworks and major psychiatric criteria and taxonomies provide a foundation for age and culturally appropriate approaches to the diagnostic evaluation, clinical decision making, and diagnostic formulations. Personality patterns are depicted along a continuum ranging from adaptive to maladaptive and are identified and explored through case examples.

471. Individual Psychotherapy
Prerequisite: NUR 470.
Credit—three hours
This course is a systematic exploration of the theory and practice of individual psychotherapy as a primary function of the advanced practice psychiatric nurse. The course builds upon the student’s knowledge of psychosocial development, mental health assessment, and psychopathology. Prevailing models of psychotherapy are analyzed, including underlying theoretical assumptions, relevant concepts, and strengths, and limitations of each model. Nursing interventions are derived from various theoretical frameworks and applied to case examples. Pertinent research and evidenced-based approaches to psychotherapy are examined and applied to advanced nursing practice. Ethical and public policy issues in nursing practice of individual psychotherapy are addressed in relation to diverse client populations.

475. Pathophysiology of Mental Illness
Prerequisite: NUR 407A (endocrinology/neurology module), or permission of instructor.
Credit—two hours
This course integrates knowledge from the neurosciences, physiology, and psychology to explore the pathophysiology of psychiatric illness. Normal and disturbed biologic rhythms, biologic theories, and the pathophysiology of major psychiatric disorders are the focal topics. Biologic hypotheses of psychiatric disorders are conceptualized, discussed, and analyzed within a multidimensional framework, with psychobiologic factors as integral components. The course provides a solid foundation for the advanced practice nurse primary mental health care provider from which to understand etiology, diagnosis, and treatment strategies for psychiatric illness.

477. Psychopharmacology
Prerequisites: NUR 419, 470 or 484, 475, or permission of instructor.
Credit—two hours
This course provides an in-depth investigation of psychopharmacologic concepts in the care of individuals and families living with major psychiatric illness. Building upon basic concepts of pharmacokinetics and pharmacodynamics, course content includes designing and implementing medication treatment regimens in collaboration with patients and their families/significant others. Direct and indirect roles of the APN around meeting the psychopharmacologic needs of patients are also discussed.

478. Theoretical Frameworks for Advanced Psychiatric Mental Health Nursing Practice
Credit—three hours
This is a foundational course that introduces students to theoretical frameworks that are applied throughout their graduate coursework in psychiatric mental health nursing. Students develop an appreciation for the importance of theory and how it is applied in advanced psychiatric mental health nursing practice. Theories that explain personality development and human behavior, the etiology of psychopathology, and mechanisms of
therapeutic change associated with major schools of psychotherapy are examined. Students gain experience in applying and analyzing theories based on research evidence and relevance to advanced practice psychiatric nursing.

479. Health Promotion and Management of Medical Morbidity in PMH Advanced Practice Nursing Credit—three hours

This course focuses on the prevalence and etiology of excess morbidity and mortality among people with serious mental illness and/or substance use disorders. Students explore factors that contribute to clients' adoption of unhealthy lifestyle habits. Emphasis is placed on integrating screening and monitoring for adverse health behaviors into advanced psychiatric nursing practice. Interdisciplinary approaches to tailoring primary, secondary, and tertiary preventive strategies to meet the needs of those with serious mental illness and/or substance use disorders are discussed. Evidence-based approaches to wellness initiatives including systems-focused and community-level interventions also are investigated.

484. Psychopathology and Psychiatric Diagnoses across the Lifespan Pre- or corequisites: NUR 435, 475, or permission of the instructor. Credit—three hours

This course provides students with a biopsychosocial framework for the advanced practice of psychiatric mental health nursing with individuals of various ages and cultural backgrounds. Students develop a perspective of the advanced practice role, with emphasis on psychiatric assessment, diagnosis, and evaluation. Students gain knowledge of evidence-based practice for common mental health problems, major psychiatric disorders, and co-occurring substance use disorders. Selected theoretical frameworks and criteria from diagnostic taxonomies provide a foundation for age-appropriate approaches to psychiatric evaluations, clinical decision making and diagnostic formulations. Personality patterns and clinical presentations are depicted along a continuum, ranging from adaptive to maladaptive, and are explored through case examples. Students apply knowledge and skills in the differential diagnosis of major psychiatric disorders and/or identification of organic causes contributing to alterations in biopsychosocial functioning for individuals of various ages and cultural backgrounds.

485. Psychotherapy across the Lifespan Prerequisite: NUR 484 or permission of the instructor; prerequisite or corequisite: NUR 435 or permission of the instructor. Credit—three hours

This course is a systematic exploration of the theory and evidence-based practice of providing psychotherapy for specific disorders and age groups across the lifespan. This course builds upon the students' knowledge of psychosocial development, mental health assessment, and psychopathology. Prevailing and evidence-based models of therapy are analyzed, including underlying theoretical assumptions, relevant concepts, strengths and limitations. Therapy models, derived from various theoretical frameworks, are applied to cases examples. The research evidence for psychotherapeutic approaches and models is examined, and implications for advanced nursing practice and research are explored. Attention is given to the ethical, legal, and public policy implications of providing psychotherapy for individuals of various ages and cultural backgrounds. This course is taught primarily online.

486. Pediatric Psychopharmacology Prerequisites: NUR 419, 475, 477, 484, or permission of instructor. Credit—two hours

This course provides an in-depth investigation of psychopharmacologic concepts applied to children, adolescents, and young adults. Neurobiological processes, pharmacodynamics, and developmental pharmacokinetics provide the basis for psychopharmacological decision making with children, adolescents, and young adults. Students incorporate the following in developing medication recommendations: diagnostic assessments, target symptoms, information regarding neurobiological circuits and neurotransmitters, practice guidelines, and the consent/assent of clients and parents/guardians. The direct and indirect roles of the advanced practice nurse in meeting the psychopharmacologic needs of clients are also discussed. This course is taught online.

487. Practicum in Advanced Child, Adolescent, and Young Adult Psychiatric/Mental Health Nurse Practitioner Role I Prerequisites: NUR 410 or 412, 484. Credit—two to three clinical hours

This course provides students with a forum to synthesize knowledge acquired throughout the curriculum, to apply that knowledge, and develop skills for practice as psychiatric mental health (PMH) nurse practitioners with children, adolescents, and young adults from diverse cultures. The purpose of the practicum is to equip students with the requisite skills to enact the role of PMH nurse practitioner through the integration of content drawn from across the curriculum. Clinical practicum seminars are held for seven meetings of two hours each (in a combination of in-person and Adobe Connect meetings) during the semester while the students are participating in precepted clinical practice. Case presentations, discussion and role-plays are utilized as integral components of clinical seminar meetings. Students incorporate evidence-based resources in evaluating clinical performance and case presentations.

488. Practicum in Advanced Child, Adolescent, and Young Adult Psychiatric/Mental Health Nurse Practitioner Role II Prerequisites: NUR 487. Credit—two to four clinical hours

Clinical practicum (112–224 hours total) will occur in specialized child and adolescent psychiatric clinical sites arranged by the program directors. Site visits and regular communication with clinical preceptors will be the responsibility of the course director and program faculty. A clinical seminar to support this practicum meets every other week. This course consists of both
in-person and virtual sessions. In-person sessions for class orientation and student presentations are required. Extended time may be necessary to accommodate all presentations on one day and are negotiated during orientation. The clinical seminar time is included in the total clinical time required in the course.

489. Practicum in Advanced Child, Adolescent, and Young Adult Psychiatric/Mental Health Nurse Practitioner Role III
Prerequisites: NUR 460 and 461 or 487 and 488.
Credit—four clinical hours

This course provides students with a forum to synthesize knowledge acquired throughout the curriculum and facilitates role and skill development for advanced psychiatric mental health nursing practice with adults and their families. Students build on prior competencies to include applying family, systems, and organizational theories in facilitating team processes; identifying opportunities for interdisciplinary collaboration, referral and consultation; recognizing system issues; and identifying influences of organizational culture on quality of care. Students integrate legal and ethical considerations in clinical decision making. Students explore the influence of public policy and develop plans for advocating for organizational and system change to promote quality outcomes within a continuum of mental health services. Clinical practicum seminars facilitate the integration of theory with precepted clinical practice. Case presentations and role-plays are utilized as integral components of seminar discussions. Students incorporate evidenced-based resources in evaluating clinical performance and case presentations.

LEADERSHIP IN HEALTH CARE SYSTEMS

Health Care Organization Management and Leadership Track

NLX 463. Driving Change in Complex Organizations
Prerequisite: NLX 470 or permission of instructor.
Credit—five hours

This course focuses on the skills necessary to lead complex organizations and builds upon the practical application of the leadership principles and theories taught in Foundations of Leadership and Organizational Development. Students explore and apply strategies for coaching, team building, and leading change within organizations. Students also learn how to create and deploy strategy to successfully guide high-performing teams in driving change. The course utilizes a highly interactive, mixed-method format that examines concepts and builds skills through team projects, class discussions, problem solving, case studies, and role-playing. Students also have the opportunity to meet with and observe current health care business leaders from a variety of organizations.

NLX 464. Informatics, Process Improvement, and Outcome Measurement
Prerequisite or corequisite: NLX 470, 471, 472, or permission of the instructor.
Credit—three hours

This course prepares students for practice in organizations characterized by automation, performance improvement, outcome measurement, and public transparency. Course content addresses information technology and application; work process design and improvement; and outcome targeting and measurement. Students meet with designated information technology professionals who demonstrate relevant computer applications and highlight their organizational value. They gain experience in linking organizational objectives to performance indicators and acquire skill in the design and implementation of models through which to evaluate outcomes against performance indicators.

NLX 465. Capstone Project and Essay
Prerequisites: NLX 463, 464, 466, 470, 471, 472
Credit—four or six hours

This project requires the synthesis and application of concepts, tools, and skills learned in the various leadership courses to a real world, executive-level project that will directly benefit an organization and a broader targeted community. Community leaders involved in the health and human service arena will guide the design, implementation, and/or evaluation of projects relevant to their organizations. Students serve as knowledge producers and problem solvers, providing the link between the academic curriculum and leadership practice. For example, the project can take the shape of a quality improvement initiative; conceptualization and development of an innovative new program; health care and/or education reform project; application of new technology to enhance service and care delivery; or an in-depth analysis of a problem with recommendations for change. Faculty members work closely with students and community leaders and serve as a resource for support and consultation on the particular project being undertaken. The field placement component of this course is three credit hours, which is equivalent 180 clock hours.

NLX 466. Epidemiology and Population Health Research
Credit—three hours

This course represents the research component of the Leadership in Health Care Systems Master’s Program and prepares students with advanced research competencies. The course presents the theoretical, methodological, and statistical concepts used in the development and evaluation of population-based health research, programs, and services; and the foundations of epidemiology and population-based practice. Emphasis is placed on application of epidemiological methods and strategies in the conduct and evaluation of population-based health research and outcomes. This course provides in-depth coverage of epidemiological principles and methods including natural history of disease, dynamics of disease etiology and transmission, measures of population morbidity and mortality, diagnostics and screening tests, risk exposure, population health disparities, structural and community-based interventions, health services evaluation, cost-effectiveness, and epidemiology and public policy.
NLX 470. Foundations of Leadership and Organizational Behavior
Credit—five hours

This course provides fundamental content in leadership and organizational behavior to assist students in individual leadership development and organizational awareness. Students explore leadership styles, behaviors, and traits required to create and maintain high levels of individual and organizational performance. Leadership roles are examined from individual, interpersonal, group, and organizational perspectives, with an emphasis on effective communication. This course also provides students with a philosophical and theoretical framework of leadership by examining historical and contemporary theories, models, and leadership styles. Students explore leadership effectiveness and its relationship to issues of power, influence, persuasion, motivation, employee performance, and ethical decision making. The course utilizes a highly interactive, mixed-method format that examines concepts and builds skills through team projects, class discussions, problem solving, case studies, and role-playing. Students also have the opportunity to meet with and observe current health care business leaders from a variety of organizations. The course includes the Writing Workshop and will help students gain proficiency in writing. It provides graduate students with the essential tools for scholarly writing. Rules of grammar, punctuation, format, and composition are reviewed and practiced. Styles of composition are analyzed and applied in writing exercises. The importance of focused presentation of ideas and clarity and progression of thought are emphasized.

NLX 471. Trends in Health Economics, Policy, and Regulation
Credit—four hours

In this course, students examine major developments in the evolution of national health policy, financing, and regulation. They explore historical, social, political, and economic trends in the evolution of the nation’s health delivery paradigm. Students analyze the impact of economic, political, and regulatory forces on health care financing, access, and utilization. Students explore prominent models of twenty-first-century health care financing and consider the viability of public support of health care delivery. They examine the nature of the country’s current health “crisis” and assess major proposals for crisis abatement.

NLX 472. Ethics and Public Mission in Contemporary Health Care Systems
Credit—three hours

In this course, students examine the delivery of health care and wellness services through an integrated delivery system. Emphasis is given to the public mission of health care networks, their constituent organizations, and the flow of populations across system levels. Students examine modes for delivery of health promotion, disease management, and acute care services. They identify access barriers, disparities in health utilization and outcomes, and gaps in service. Students explore critical issues confronting health systems in twenty-first-century society.

NLX 479. Leadership Colloquium
Prerequisite or corequisite: NLX 463, 464, 466, 470, 471, 472, or permission of the instructor.
Credit—three hours

This course serves as an “intellectual forum” in which graduate students explore complexities inherent in organizational leadership. The colloquium features a focal topic each week, selected to highlight leadership challenges encountered in organizational settings. Visiting lecturers, renowned for their outstanding leadership ability, offer prepared commentary on the topic. Lecturers are drawn from the University, corporations, business alliances, health and human service agencies, and Rochester’s legislative delegation. After each colloquium session, students prepare individually written statements of practice principles culled from the discussion. At the end of the semester, students submit a “Compendium of Leadership Principles” in satisfaction of a colloquium requirement.

NLX 493. Comp Exam
Credit—none

A comprehensive examination is required for all master’s students. Successful completion of a comprehensive examination demonstrates students’ abilities to integrate knowledge gained through individual courses into critical thinking and advanced practice. Students enroll and complete the exam during the last semester of their academic coursework.

CLINICAL NURSE LEADER TRACK

400. Research Principles for Evidence-Based Advanced Practice
Credit—five hours

This course is designed to prepare advanced practice nurses in applying evidence to practice and using evidence to drive clinical decision making. Students learn the foundations of research methods that underlie evidence-based practice. The course focuses on developing clinical questions, analyzing clinical data, evaluating pertinent research, and developing practice recommendations. Students explore outcomes in the contexts of professional practice and population management. Students gain a greater appreciation of how theory and practice articulate and how best to apply theory to a clinical problem.

401. The Writing Workshop
Credit—one hour

The purpose of this course is to help students gain proficiency in writing. It provides graduate students with the essential tools for scholarly writing. Rules of grammar, punctuation, format, and composition are reviewed and practiced. Styles of composition are analyzed and applied in writing exercises. The importance of focused presentation of ideas, and clarity and progression of thought are emphasized.

403. Ethics and Public Policy in the Health Care System
Credit—three hours

This foundational course provides an overview of the structure, regulation, and financing of the health care system in the United
States. Nursing’s past and present contributions and its potential to shape future health care are evaluated. Contemporary health care and policy issues are examined using concepts and principles of planned change, ethical decision making, the policy process, and policy analysis.

407A. Physiological and Pathophysiological Basis of Advanced Nursing Practice
Prerequisite: undergraduate anatomy and physiology.
Credit—five hours
A study of those physiologic processes that are a basis for advanced nursing practice. The focus is on regulatory mechanisms that maintain homeostasis. Content is based on theories from physiologic and immunologic research. This course is offered with varying credit and consists of Unit I, cell physiology and immunology; Unit II, neurophysiology and endocrinology; Unit III, cardiovascular and respiratory physiology; and Unit IV, renal and gastrointestinal physiology.

410. Advanced Health Assessment
Prerequisite: prior health assessment coursework or refresher.
Credit—four or six hours (two of which are lab)
This graduate-level course provides the theoretical and clinical foundation for advanced comprehensive assessment of the health status of individuals and families. Building on undergraduate preparation, principles of complex interviewing, and history taking; diagnostic reasoning; and advanced physical, psycho-social, cultural, developmental, and environmental assessments are presented. From a functional and developmental base, the course emphasizes techniques for discrimination and analysis of common abnormal findings, the process of differential diagnosis, and methods for presentation of findings. Theoretical contexts of health promotion are discussed and applied to clinical findings. This course includes laboratory modules for specialty skill instruction.

419. Advanced Pharmacology
Prerequisites: introductory human physiology and pharmacology. Unit I prerequisite to Unit II.
Credit—three hours
This is an advanced course in pharmacology that includes Unit I—one credit of online course material including interpretation of New York State and federal laws and regulations pertaining to prescribing drugs and record keeping; and Unit II—two credits of pharmacokinetics, pharmacotherapeutics, and clinical decision making in drug management for the advanced practice of nursing.

NLX 464. Informatics, Process Improvement, and Outcome Measurement
Prerequisite or Corequisite: NLX 472, 471, 470 or permission of the instructor.
Credit—three hours
This course prepares students for practice in organizations characterized by automation, performance improvement, outcome measurement, and public transparency. Course content addresses information technology and application; work process design and improvement; and outcome targeting and measurement. Students meet with designated information technology professionals who demonstrate relevant computer applications and highlight their organizational value. They gain experience in linking organizational objectives to performance indicators and acquire skill in the design and implementation of models through which to evaluate outcomes against performance indicators.

NLX 465. Capstone Project and Essay
Prerequisites: NUR 403, 407A, 410, 419, NLX 466, 470, 475
Credit—six hours
This project requires the synthesis and application of concepts, tools, and skills learned in the various leadership courses to a real-world, executive-level project that will directly benefit an organization and a broader targeted community. Community leaders involved in the health and human service arena guide the design, implementation, and/or evaluation of projects relevant to their organizations. Students serve as knowledge producers and problem solvers, providing the link between the academic curriculum and leadership practice. For example, the project can take the shape of a quality improvement initiative; conceptualization and development of an innovative new program; health care and/or education reform project; application of new technology to enhance service and care delivery; or an in-depth analysis of a problem with recommendations for change. Faculty members work closely with students and community leaders and serve as a resource for support and consultation on the particular project being undertaken. The field placement component of this course is four credit hours, which is equivalent to 300 clock hours, which may be across two semesters.

NLX 466. Epidemiology and Population Health Research
Credit—three hours
This course represents the research component of the Leadership in Health Care Systems Master’s Program and prepares students with advanced research competencies. The course presents the theoretical, methodological, and statistical concepts used in the development and evaluation of population-based health research, programs and services; and the foundations of epidemiology and population-based practice. Emphasis is placed on application of epidemiological methods and strategies in the conduct and evaluation of population-based health research and outcomes. This course provides in-depth coverage of epidemiological principles and methods including natural history of disease, dynamics of disease etiology and transmission, measures of population morbidity and mortality, diagnostics and screening tests, risk exposure, population health disparities, structural and community-based interventions, health services evaluation, cost-effectiveness, and epidemiology and public policy.

NLX 475. Leadership in Clinical Nursing
Credit—four hours
This course introduces students to the role and responsibilities of a clinical nurse leader (CNL). Leadership skills are discussed within the broader framework of system change and quality
improvement. The emphasis is on working with interdisciplinary teams to create and shape effective health care delivery systems responsive to the needs of individuals and families.

**NLX 493. Comp Exam**  
_Credit—one hour_  
A comprehensive examination is required for all master’s students. Successful completion of a comprehensive examination demonstrates students’ abilities to integrate knowledge gained through individual courses into critical thinking and advanced practice. Students enroll and complete the exam during the last semester of their academic coursework.

**Clinical Research Coordinator Track**  
**NLX 465. Capstone Project**  
_Credit—one hour_  
This project requires the synthesis and application of concepts, tools, and skills learned in the various leadership courses to a real-world, executive-level project that will directly benefit an organization and a broader targeted community. Students apply knowledge and skill acquired in graduate coursework in implementing, overseeing, administering, and evaluating a clinical research project. Their work is carried out with the guidance of a project preceptor, typically program faculty or other faculty members or an affiliated health organization or industry. These leaders guide the design, implementation, and/or evaluation of projects relevant to their organizations. Students serve as knowledge producers and problem solvers, providing the link between the academic curriculum and leadership practice. For example, the project can take the shape of a quality improvement initiative; conceptualization and development of an innovative new program; health care and/or education reform project; application of new technology to enhance service and care delivery; or an in-depth analysis of a problem with recommendations for change. Faculty members work closely with students and community leaders and serve as a resource for support and consultation on the particular project being undertaken. The field placement component of this course is three credit hours, which is equivalent to fifteen hours for 12 weeks during the spring semester for a total of 180 clock hours.

**NLX 466. Epidemiology and Population Health Research**  
_Credit—one hour_  
This course represents the research component of the Leadership in Health Care Systems Master’s Program and prepares students with advanced research competencies. The course presents the theoretical, methodological, and statistical concepts used in the development and evaluation of population-based health research, programs and services; and the foundations of epidemiology and population-based practice. Emphasis is placed on application of epidemiological methods and strategies in the conduct and evaluation of population-based health research and outcomes. This course provides in-depth coverage of epidemiological principles and methods including natural history of disease, dynamics of disease etiology and transmission, measures of population morbidity and mortality, diagnostics and screening tests, risk exposure, population health disparities, structural and community-based interventions, health services evaluation, cost-effectiveness, and epidemiology and public policy.

**NLX 479. Leadership Colloquium**  
_Prerequisite or Corequisite: NLX 466, 480, 481, 482, 483, 484, or permission of the instructor._  
_Credit—one hour_  
This course serves as an “intellectual forum” in which graduate students explore complexities inherent in organizational leadership. The colloquium features a focal topic each week, selected to highlight leadership challenges encountered in organizational settings. Visiting lecturers, renowned for their outstanding leadership ability, offer prepared commentary on the topic. Lecturers are drawn from the University, corporations, business alliances, health and human service agencies, and Rochester’s legislative delegation. After each colloquium session, students prepare individually written statements of practice principles culled from the discussion. At the end of the semester, students submit a “Compendium of Leadership Principles” in satisfaction of a colloquium requirement.

**NLX 480. Clinical and Translational Research Design**  
_Credit—one hour_  
This course prepares clinical research coordinators to successfully implement and manage a range of clinical and translational research designs. Requirements and design elements of research projects are reviewed within the context of scientific rigor, study integrity, and internal validity. Randomized clinical trials, a variety of quasi-experimental designs, cohort (prospective and retrospective), factorial, crossover, case-control, and other selected designs are reviewed. In addition, community participatory research and translational models are examined. Research reporting guidelines for these study designs (e.g., CONSORT statement for RCTs) are also covered. Simple statistical methods associated with the various research designs are reviewed.

**NLX 481. Ethical Foundations and Issues in Human Subject Research**  
_Credit—one hour_  
This course addresses sampling, recruitment, and follow-up procedures, as well as the protection of human subjects. Content includes preparation and implementation of enrollment protocols, subject eligibility and screening, vulnerable subjects, voluntary informed consent, Institutional Review Board (IRB) regulations, submission and approval, ICH good clinical practice (GCP) guidelines, adverse event monitoring and reporting, NCI data safety and monitoring guidelines and study termination rules. Related topics in bioethics are addressed throughout the course, including subject compensation, scientific integrity and misconduct, privacy and confidentiality, conflict of interest, and minority participation in research.
**NLX 482. Product Development in the Pharmaceutical, Device, and Biologics Industry**  
**Credit—four hours**

Students focus on the process and skill dimensions of successful leader interventions. This course focuses on the process by which drugs, devices, biologics, and medical procedures are conceived, developed, and tested in clinical trials. The role of industry in facilitating clinical research is considered. Content incorporates a range of protocols including pharmacological, surgical, clinical, and biomedical interventions. Pertinent topics include intervention development, manual writing, administration, quality control, fidelity, dosage and dose-finding, adverse effects monitoring, inventory control treatment compliance and adherence, placebo effects, drop-out and ITT protocol, and clinical practice and monitoring. Intervention administration, monitoring, and regulatory policy, including FDA guidelines are discussed. Various intervention delivery settings are explored including hospitals, clinics, chronic care facilities, home visits, and communities.

**NLX 483. Research Project Management in Complex Health Care Systems**  
**Credit—five hours**

This course provides knowledge and skills to manage all phases of research projects, including project start-up, protocol development, standard operating procedures, documentation, workflow, staff hiring, training and supervision, budget and expenditures, contract management, regulatory guidelines, and project close-out. The course covers the structure and interactions among academic, corporate, government, and community organizations involved in research, as well as multisite project management. Translation of clinical research to patients and communities and leadership skills are also addressed.

**NLX 484. Research Data Collection and Intervention Administration in Clinical Practice**  
**Prerequisite: NLX 482.**  
**Credit—four hours**

This course covers intervention administration, monitoring, regulatory policy, and data management in clinical research. A range of intervention protocols is considered but behavioral interventions are highlighted. The development and implementation of interventions including protocol development and administration, quality control, monitoring, and oversight are covered. Data management including sources and methods of data collection, storage, management, and reporting strategies are considered. Database creation and structure, and data warehousing, management, and mining techniques are also explored. Regulations pertaining to personal health information (PHI) protection and confidentiality as required by HIPAA and other regulatory bodies are covered. Simple statistical analyses for data monitoring and reporting are also covered. These topics are considered in the context of the clinical practice setting.

**NLX 493. Comp Exam**  
**Credit—none**

A comprehensive examination is required for all master’s students. Successful completion of a comprehensive examination demonstrates students’ abilities to integrate knowledge gained through individual courses into critical thinking and advanced practice. Students enroll and complete the exam during the last semester of their academic coursework.

**DNP PROGRAM**

**464. Informatics, Process Improvement, and Outcome Measurement**  
**Prerequisite or Corequisite: NLX 472, 471, 470 or permission of the instructor.**  
**Credit—three hours**

This course prepares students for practice in organizations characterized by automation, performance improvement, outcome measurement, and public transparency. Course content addresses information technology and application; work process design and improvement; and outcome targeting and measurement. Students meet with designated information technology professionals who demonstrate relevant computer applications and highlight their organizational value. They gain experience in linking organizational objectives to performance indicators and acquire skill in the design and implementation of models through which to evaluate outcomes against performance indicators.

**466. Epidemiology and Population Health Research**  
**Credit—three hours**

This course represents the research component of the Leadership in Health Care Systems Master’s Program and prepares students with advanced research competencies. The course presents the theoretical, methodological, and statistical concepts used in the development and evaluation of population-based health research, programs and services; and the foundations of epidemiology and population-based practice. Emphasis is placed on application of epidemiological methods and strategies in the conduct and evaluation of population-based health research and outcomes. This course provides in-depth coverage of epidemiological principles and methods including natural history of disease, dynamics of disease etiology and transmission, measures of population morbidity and mortality, diagnostics and screening tests, risk exposure, population health disparities, structural and community-based interventions, health services evaluation, cost-effectiveness, and epidemiology and public policy.

**NLX 471. Trends in Health Economics, Policy, and Regulation**  
**Credit—four hours**

In this course, students examine major developments in the evolution of national health policy, financing, and regulation. They explore historical, social, political, and economic trends in the evolution of the nation’s health delivery paradigm. Students analyze the impact of economic, political, and regulatory forces
on health care financing, access, and utilization. Students explore prominent models of twenty-first-century health care financing and consider the viability of public support of health care delivery. They examine the nature of the country’s current health “crisis” and assess major proposals for crisis abatement.

572. Ethics and Public Mission in Contemporary Health Care Systems  
Credit—three hours

In this course, students examine the delivery of health care and wellness services through an integrated delivery system. Emphasis is given to the public mission of health care networks, their constituent organizations, and the flow of populations across system levels. Students examine modes for delivery of health promotion, disease management, and acute care services. They identify access barriers, disparities in health utilization and outcomes, and gaps in service. Students explore critical issues confronting health systems in twenty-first-century society

480. Clinical and Translational Research Design  
Credit—four hours

This course prepares clinical research coordinators to successfully implement and manage a range of clinical and translational research designs. Requirements and design elements of research projects are reviewed within the context of scientific rigor, study integrity, and internal validity. Randomized clinical trials, a variety of quasi-experimental designs, cohort (prospective and retrospective), factorial, crossover, case-control, and other selected designs are reviewed. In addition, community participatory research and translational models are examined. Research reporting guidelines for these study designs (e.g., CONSORT statement for RCTs) are also covered. Simple statistical methods associated with the various research designs are reviewed.

510. General Linear Approaches I  
Credit—three hours

This course provides discussion and application of descriptive and inferential statistics, correlation and regression, analysis of variance, nonparametric, and distribution-free statistics.

573. Interprofessional Partnerships  
Credit—three hours

This course is designed to strengthen students’ analytic skills in evaluating the effects of interprofessional collaboration on health care team and microsystem performance, patient safety, and quality improvement. Students synthesize information from a broad interdisciplinary literature base to assess and evaluate barriers and facilitators to interprofessional collaboration for patient-centered care. The effectiveness of interventions designed to improve such collaboration is explored and analyzed. Students are expected to critically examine their experiences as interprofessional team members and leaders in clinical practice.

574. Strategic Planning and Evaluation of Hospital Health Care Delivery Systems  
Credit—three hours

This course provides students with the skills necessary for measuring and monitoring outcomes of individuals and organizations within diverse health care systems. Administrative, organizational, systems, and evaluation theories are examined for application to health care strategic planning and decision-making activities. Applied research and theory-derived evaluation methods are used to explore student-identified questions of relevance to health delivery systems.

584. DNP Practicum I  
Credit—three hours (two clinical hours)

This course provides students with learning experiences in a variety of clinical settings tailored to the student’s identified area of specialization. Such experiences are intended to support students in the analysis, application, and evaluation of knowledge gained through foundational DNP coursework in clinical practice. Biweekly faculty-led seminars are designed to assist students to reflect on best practice approaches and their consequences and generate solutions for creatively dealing with barriers that interfere with the delivery of equitable, evidence-based, patient-centered care.

585. DNP Practicum II  
Prerequisite: NUR 584.  
Credit—three hours (two clinical hours)

This course builds on the DNP Practicum I by continuing to provide students with learning experiences in a variety of clinical settings tailored to the student’s identified area of specialization. The application and integration of knowledge gained through foundational DNP coursework continues with emphasis on the use of information systems and technology to support and improve health care system functioning and care delivery. Biweekly faculty-led seminars are designed to assist students to reflect on best practice approaches and their consequences and generate solutions for creatively dealing with barriers that interfere with the delivery of equitable, evidence-based, patient-centered care.
586. DNP Policy Practicum  
Prerequisite: NUR 584, 585.  
Credit—three hours (two clinical hours)  
Building on course content, this practicum provides students with direct exposure to public and private sector roles in health policy development and experience advising policy makers about health care issues.

587. DNP Residency and Capstone Project  
Prerequisite: NUR 584, 585, 586.  
Credit—ten hours (four–five clinical hours)  
Building upon prior practicum experiences, the DNP residency is an end-of-program practice immersion experience to foster continued knowledge assimilation for advanced specialty practice at a high degree of complexity. Biweekly faculty-led seminars are designed to assist students to reflect on best practice approaches and their consequences and generate solutions for creatively dealing with barriers that interfere with the delivery of equitable, evidence-based, patient-centered care. Independent work with a mentor culminates in completion of the DNP Capstone Project.

PHD PROGRAM

505. Epistemology and Concept Development  
This course examines the epistemological debates about science in current nursing and health care literature. These debates reflect different ways of knowing and arise out of different philosophical traditions, such as rationalism, empiricism, historicism, and organicism. An understanding of these debates informs the discussion about the nature of science and theory. Different approaches to concept development are explored in the context of their philosophical foundations. Students will apply the process of concept development to a specific area of interest.

506. Epistemology and Theory Construction  
Credit—three hours  
This course examines epistemology debates about science in current nursing and health care literature. The debates reflect different ways of knowing and arise out of different philosophical traditions such as pragmatism, phenomenology, hermeneutics, post-structuralism and critical theory. The process of theory construction is examined from logical, inductive and deductive approaches. The interrelationships between concepts, constructs, and variables are explicated for considering how study designs area generated. Students will apply knowledge gained about the process of theory construction to a specific area of interest.

507. Research Appraisal and Synthesis  
Credit—three hours  
This course is designed to review existing programs of research among faculty and in the research literature, and to provide practice in collecting, appraising, and synthesizing published research evidence in an area of student interest. In both activities, students consider the relationships between theory and research and between research questions and study designs.

508. Writing and Publishing in the Health Sciences  
Credit—two hours  
The primary focus of this course is to prepare students to successfully disseminate research findings in the form of published articles in peer-reviewed scientific journals. This course provides students with both scholarly and practical knowledge on writing and publishing scientific manuscripts. It covers the publishing process, as well as techniques for writing clear and well-organized manuscripts, and ethical issues involving manuscript preparation and publication.

510. General Linear Approaches I  
Credit—three hours  
This course provides discussion and application of descriptive and inferential statistics, correlation and regression, analysis of variance, nonparametric, and distribution-free statistics.

511. Basic Quantitative Methods  
Credit—three hours  
This course covers basic principles of research design with human subjects. The topics covered include the analysis of causal relationships; threats to internal and external validity; experimental, quasi-experimental, relational, and descriptive designs. Attention will be given to formulation of research questions and hypotheses, sampling design, control and comparison groups, stratification and factorial designs, survey designs, and case control and cohort study designs. Students will be introduced to designing an a priori analytic plan for the various types of studies.

512. General Linear Approaches II  
Credit—three hours  
This course presents advanced techniques for the statistical analysis of multiple quantitative variables. These techniques are particularly applicable to investigation of the complex relationships characteristic of nursing problems and other behavioral science questions. Building on General Linear Approaches I, topics include multiple regression, structural equations, logistic analysis, and multivariate techniques. The emphasis is practical, with a focus on the analysis of actual data.

513. Research Measurement  
Credit—three hours  
This course is a continuation of the qualitative approach to nursing research begun in NUR 511. The emphasis is on the principles of measurement and their application to problems in nursing research. There is also a strong emphasis on data analysis, using existing data sets and widely available software packages. The format follows that of a seminar rather than lectures. Students present case studies and evaluate instruments.

514. Research Integration and Proposal Development  
Credit—three hours  
The course provides students an opportunity to integrate material from courses in cognate areas, research methods, statistics, and clinical nursing research against the context of
environmental, professional, and ethical realities. Issues examined include protection of and access to human participants for research, collaborative roles, research funding, and publication. Learning experiences include examination of published research and reviews of research in the student's area of interest, presentations of preliminary plans for a research project, preparation of a formal written research proposal, and peer review of a student colleague's research proposal.

517. Teaching and Learning in Nursing  
Credit—three hours

The course provides an introduction to the principles of teaching and evaluation strategies. The course includes educational theories, teaching strategies, learning activities, and evaluation strategies.

525. An Introduction to Structural Equation Modeling  
Credit—three hours

The course is designed to provide an introduction to the area of latent variable analysis in which causal models involving one or more unmeasured variables are fit to data. It represents a conceptually unified treatment of path analysis, confirmatory factor analysis, and structural equation analysis. It provides an introduction to the LISREL and AMOS statistical software packages, two of the most widely used programs for fitting structural equation models. The course focuses on an understanding of what these programs do, rather than on the particular details of their input and output. Elementary matrix algebra is occasionally employed to understand the underlying structure of the analyses.

530. Coping with Physical Illness

This course focuses on the exploration of the utility of psychological theoretical orientations (e.g., appraisal, information processing, and social learning theories) to explain coping with physical illness. A seminar format is used.

531. Seminar in Theories that Guide Research in High-Risk Children and Youth  
Credit—three hours

Seminar for PhD students and postdoctoral fellows in the area of High-Risk Children and Youth (other graduate-level students, by permission of faculty). The seminar focuses on discussion and integration of theories that guide clinical research at the individual, family, and community levels, and are directly applicable to research of children, youth, and families. Human Ecology Theory is the overarching theory for the seminar. Individual level theories include coping and self-regulation, self-efficacy, behavior change (value expectancy), resilience, cognitive representation, and self-agency theories. Family level theories include relationship, attachment, separation/individuation, and peer/family theories. Community level theories include organizational, systems change, community and environmental, and cultural effect theories.

532. Advanced Seminar in Intervention Research for High-Risk Children and Youth  
Credit—three hours

Seminar for all PhD students and postdoctoral fellows in the area of High-Risk Children and Youth (other graduate-level students by permission of faculty). This seminar focuses on effective strategies for the design, implementation, execution, and analysis of interventions for amelioration of threats to the health of children, youth, and families. Topics covered include efficacy and effectiveness stages in research, challenges of randomized trials in community settings, establishing fidelity in interventions, selecting effective outcome measures, temporality of measurement, determination of potential for change, the role of moderators and mediators in understanding the process of intervention effectiveness, building cultural sensitivity into intervention research, and cost analyses/effectiveness of interventions.

541. Theory and Research on Health Behavior  
Credit—three hours

Behavior has a central role in the world's major health problems. This seminar focuses on discussion and integration of theories that guide the study of health behaviors and interventions. Models of individual, interpersonal, and social health behavior and behavior change are discussed, and the underlying mechanisms for health disparities are considered, in the context of faculty and student research interests.

544. Advanced Biostatistics  
Credit—three hours

This course provides an introduction to advanced biostatistics and applications of selected advanced techniques to data. The course covers structural equation modeling, multilevel modeling, missing data imputation, and survival analysis. Other topics may be included, depending on interests. Actual data sets are used as examples and students are guided in the design and analysis of the data.

545. Research Using Existing Data  
Credit—three hours

The goal of the course is to learn to evaluate existing data, conduct data analysis using a large dataset, and understand issues in developing research programs using existing data. The topics and issues examined include sources and advantages and disadvantages of existing data, the process of obtaining data, appraisal and use of existing data, and conceptual, methodological, and statistical considerations. Statistical methods including multilevel modeling and analysis of complex survey data are also introduced.

546. Conducting Research with Older Persons: Methods and Applications  
Credit—three hours

The purpose of this course is to familiarize students with unique and prevalent issues, problems, difficulties, and challenges of conducting health services research with elderly persons, and to provide students with approaches and tools to address those issues.
and problems in order to successfully conceptualize, plan, carry out, and conclude research on or with the aged. This course focuses almost exclusively on persons age 65 and older, with special attention being paid to the old-old (those age 85 and over), people with cognitive impairment, and residents of nursing homes.

547. Conducting Research with Older Persons: Methods and Applications II—Nursing Homes  
Credit—three hours  
This course is designed to provide an overview of critical practice and policy issues that influence the direction of nursing home research focused on care of the elderly. It includes discussion of nursing home issues within the broader context of long-term care in the United States; categories of research that have influenced care of nursing home residents and public policy; issues of designing and conducting nursing home research; and areas needing further investigation.

548. Advanced Seminar on Dementia Research in Older Adults  
Credit—three hours  
This course is designed to provide an overview of dementia research related to the advancement of clinical practice. It includes discussion of healthy aging, disease processes that lead to dementia, and issues involved in the care and treatment of cognitively impaired older adults in a variety of settings. Objectives address critical analysis and evaluation of the adequacy and the challenges of dementia research and identifying areas in need of further study.

555. Basic Qualitative Methods  
Credit—three hours  
This course introduces the student to the field of qualitative research and covers basic principles of research design with an emphasis on the appropriate use of methods. The primary focus is on approaches that are common to the design, conduct, and reporting of qualitative research across genres. Attention also is given to the different purposes and approaches of specific genres through readings and examples of work representing the three major traditions of ethnography, grounded theory, and phenomenology.

556. Advanced Qualitative Research Methods: Qualitative Description and Content Analysis  
Credit—three hours  
This course builds on prior coursework in or equivalent to NUR 555, an overview and introduction to basic qualitative methods. This advanced course extends foundational knowledge by enabling learners to examine in depth qualitative descriptive design and the analytic technique of content analysis and apply these to their own practice-related research. This course is one of a series of seminars on qualitative methods topics offered periodically based on student interest. Qualitative description is the most commonly used approach to qualitative research but has only recently been labeled and described. The origins and historical and philosophical placement of qualitative description are explored. Processes and strategies for research question development, data collection, and data analysis are examined and practiced. Specific technical issues related to the definition of the research problem, sample selection, data gathering, analysis, interpretation, and reporting are experienced by the learner through hands-on involvement in a student-defined research project.

557. Advanced Qualitative Research Methods: Ethnography  
Credit—three hours  
This course builds on prior introductory coursework in basic qualitative methods. The advanced course extends foundational knowledge through opportunities for learners to examine one specific approach in depth as it relates to their own practice-related research. This course is one of a series of seminars on qualitative methods topics offered periodically based on student interest. Processes and strategies for inquiry are examined and practiced within the context of the theoretical underpinnings and the historical and philosophical perspectives of the ethnographic approach including structural, interpretive, and critical ethnography including feminist ethnography. Specific issues related to the definition of the research problem, sample selection, participant observation, description, analysis, interpretation, and ethnographic writing are experienced by the learner through practical involvement in a self-defined research project.

558. Advanced Qualitative Research Methods: Grounded Theory  
Credit—three hours  
This course builds on prior coursework in or equivalent to NUR 555, an overview and introduction to basic qualitative methods. This advanced course extends foundational knowledge by enabling learners to examine the grounded theory approach in depth and apply this method to their own practice-related research. This course is one of a series of seminars on qualitative methods topics offered periodically based on student interest. The theoretical underpinnings and historical and philosophical perspectives of the grounded theory approach are explored. Processes and strategies for research question development, data collection, and data analysis within grounded theory are examined and practiced. Specific technical issues related to the definition of the research problem, sample selection, data gathering, analysis, interpretation, and reporting are experienced by the learner through hands-on involvement in a student-defined research project.

560. Role of the Clinical Researcher  
Credit—none  
Drawing on presentations from researchers in the School of Nursing, students are provided with the opportunity to study the career trajectories of researchers and examine the interplay between need for specific knowledge in a field to guide clinical practice or develop a health service and the research that can be undertaken. Emphasis is placed on developing career trajectories that bring the skills of the researcher together with the needs for quality care. Presentations are designed also to help students to conceptualize their own research questions, driven by their “need to know” in order to provide evidence-based care in clinical practice.
590. Dissertation Workshop
Credit—none

The purpose of the Dissertation Workshop is to help students who have completed their coursework sustain momentum in the completion of doctoral program requirements. It provides a regular, organized opportunity, with faculty guidance, to present work in progress on the part II Qualifying Examination and/or dissertation and to receive feedback from faculty and doctoral students who are at similar or different stages of their doctoral program.

591. PhD Reading Course
Credit to be arranged (usually not to exceed three hours)

595. Research for Doctoral Dissertation
Credit to be arranged

For further information, contact:
Office of Student Affairs
University of Rochester School of Nursing
601 Elmwood Avenue, Box SON
Rochester, New York 14642-0001
(585) 275-2375
William E. Simon Graduate School of Business Administration

Administrative Officers

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Delores Conway, PhD
Associate Dean for Master’s Programs

Hollis S. Budd, BS
Associate Dean for MBA Administration and External Relations

PhD Committee

The PhD Committee is composed of faculty from the various concentration areas and is currently chaired by Toni M. Whited.

Faculty

James A. Brickley, PhD (Oregon)
Gleason Professor of Business Administration and Professor of Economics and Management and of Finance

Delores Conway, PhD (Stanford)
Professor of Statistics and Real Estate Economics

Rajiv M. Dewan, PhD (Rochester)
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Professor of Finance and Economics

John B. Long, Jr., PhD (Carnegie Mellon)
Frontier Communications/Rochester Telephone Professor of Business Administration and Professor of Finance and Economics

Duncan T. Moore, PhD (Rochester)
Vice Provost for Entrepreneurship, Rudolf and Hilda Kingslake Professor of Optical Engineering, Professor of Biomedical Engineering and of Business Administration

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Louise and Henry Epstein Professor of Business Administration and Professor of Finance and Economics

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Fred H. Goven Professor of Business Administration and Professor of Finance

Toni M. Whited, PhD (Princeton)
Michael and Diane Jones Professor of Business Administration and Professor of Finance

Jerold L. Zimmerman, PhD (California, Berkeley)
Ronald L. Bittner Professor of Business Administration and Professor of Accounting

Mark Zupan, PhD (MIT)
Professor of Economics and of Public Policy
associate professor

Gregory C. Dobson, PhD (Stanford)
Associate Professor of Operations Management

Harry Groenevelt, PhD (Columbia)
Associate Professor of Operations Management

Ron Kaniel, PhD (University of Pennsylvania)
Associate Professor of Finance

Phillip J. Lederer, PhD (Northwestern)
Associate Professor of Operations Management

Sanjog R. Misra, PhD (SUNY, Buffalo)
Associate Professor of Marketing and Applied Statistics

Edieal J. Pinker, PhD (MIT)
Associate Professor of Computers and Information Systems and of Operations Management

Michael A. Raith, PhD (London School of Economics and Political Science)
Associate Professor of Economics and Management

Gerard J. Wedig, PhD (Harvard)
Associate Professor of Business Administration

Joanna Shuang Wu, PhD (Tulane)
Associate Professor of Accounting

assistant professor

Paulo Albuquerque, PhD (California, Los Angeles)
Assistant Professor of Marketing

Paul Ellickson, PhD (MIT)
Assistant Professor of Economics and of Marketing

Shane Heitzman, PhD (Arizona)
Assistant Professor of Accounting

Anzhela Knyazeva, PhD (New York University)
Assistant Professor of Finance

Diana Knyazeva, PhD (New York University)
Assistant Professor of Finance

Leonard Kostovetsky, PhD (Princeton)
Assistant Professor of Finance

Mitchell J. Lovett, PhD (Duke)
Assistant Professor of Marketing

Susan Feng Lu, PhD (Northwestern University)
Assistant Professor of Economics and Management

Ryan McDevitt, PhD Candidate (Northwestern University)
Assistant Professor of Economics and Management

Jeanine Miklós-Thal, PhD (University of Toulouse 1)
Assistant Professor of Economics and of Marketing

Boris Nikolov, PhD (University of Lausanne)
Assistant Professor of Finance

Robert Novy-Marx, PhD (University of California, Berkeley)
Assistant Professor of Finance

Edward Owens, PhD Candidate (University of North Carolina, Chapel Hill)
Assistant Professor of Finance

Robert Ready, PhD (University of Pennsylvania)
Assistant Professor of Accounting

Minjae Song, PhD (Harvard University)
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Tolga Tezcan, PhD (Georgia Tech.)
Assistant Professor of Operations Management

Vera Tilson, PhD (Case Western Reserve University)
Assistant Professor of Operations Management

clinical faculty

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William H. Meckling Professor of Business Administration and Clinical Professor of Business Administration

Roy Jones, PhD (Stanford)
Clinical Assistant Professor of Computers and Information Systems

Paul E. Nelson, PhD (Rochester)
Clinical Professor of Marketing

Werner Schenk, MBA (Rochester)
Clinical Assistant Professor of Computing and Information Systems

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Janice M. and Joseph T. Willett Professor of Business Administration for Teaching and Service and Clinical Professor of Economics and Management

Heidi Tribunella, MS (SUNY Institute of Technology)
Clinical Associate Professor of Accounting

Charles E. Wasley, PhD (The University of Iowa)
Joseph and Janice Willett Distinguished Scholar and Clinical Professor of Accounting

Kurt Wojdat, PhD (University of Buffalo)
Clinical Assistant Professor of Accounting

Ellen Zuroski, MS (Rochester)
Clinical Assistant Professor of Business Communications

executive professor

George R. Cook, MBA (Ohio State University)
Executive Professor of Business Administration

Dennis Kessler, MSL (Yale)
Executive Professor of Business Administration

Lawrence J. Matteson, MBA (Rochester)
Executive Professor of Business Administration

David J. Oliveira, MBA (Rochester)
Executive Professor of Business Administration

lecturer

Daniel J. Burnside, PhD (Cornell)
Lecturer in Finance

Barry A. Friedman, PhD (Ohio State)
Lecturer in Economics and Management

W. Barry Gilbert, MBA (Rochester)
Executive Lecturer in Business Administration and E-Commerce

Paul F. Shanahan, JD (Albany)
Lecturer in Business Law

Frank Torchio, MBA (Rochester)
Lecturer in Finance and Economics

Mark Wilson, MS (RPI)
Lecturer in Entrepreneurship
Perspective

The William E. Simon Graduate School of Business Administration has a faculty of 68, including individuals specifically trained in the functional areas of accounting, competitive and organizational strategy, finance, computers and information systems, health sciences, marketing, e-commerce, and operations management, as well as attorneys, economists, mathematicians, and statisticians.

Five key components make the Simon School one of the world's top business schools, and together contribute to our success in developing tomorrow's leaders.

1. Over four decades, the Simon School's world-class faculty have made enormous contributions that have revolutionized the kinds of questions asked in business and changed how countless companies and executives in the United States and abroad conduct business. Our economics-based approach to problem solving and the way faculty integrate topics in our cross-functional curriculum are distinguishing features of the School.

2. Admission is highly competitive. We strive to have selectivity as well as diversity.

3. The Simon School maintains its small size. We enroll just over 900 students in the full- and part-time and executive MBA, MS, and PhD programs.

4. The Simon School stresses preparation for a lifetime of work in business—analytical skills, thinking across functions, understanding what motivates people, working effectively on teams, and developing management communication skills.

5. At the Simon School, opportunities to lead others are extremely varied.

Master of Business Administration Program

Program of Study

To earn the MBA degree, 67 credit hours of study (64 credit hours for part-time study) with a 3.0 grade point average must be completed. The MBA program normally involves six quarters of full-time study, but exceptional students are able to complete it in a shorter period. All MBA students have the option of taking a 21st and 22nd course free of charge within a year of completing the program.

The MBA curriculum consists of nine required core courses, 11 electives, and a management communication sequence taken over three quarters (full-time students only). Although students are not required to complete a concentration, most opt for at least one, and in many cases two. Concentrations permit students to develop expertise in specific areas.

For more information about the Simon School's MBA program, please visit us online at www.simon.rochester.edu/.

Master of Science in Business Administration, Master of Science in Finance, and Master of Science in Accountancy

The master’s degree program offers six concentrations: manufacturing management, service management, information systems management, general management, marketing, and medical management.

The Simon School also offers the Master of Science in finance and the Master of Science in accountancy programs.

The manufacturing and service management programs provide management training for individuals who wish to remain in those areas. They can help operations managers and industrial or manufacturing engineers gain further expertise in operations management and stay current with the most recent developments in the field. Designed for individuals involved in operations, in manufacturing, or in service firms, these programs are more technical than the general MBA degree and may be earned by someone who already has an MBA without an operations management concentration. These programs require 39 credit hours of study.

The information systems management program is appropriate for professionals who are committed to careers in information systems and who need management expertise. The program emphasizes both management principles and an understanding of the modern technical aspects of information systems, which facilitate the integration of information systems into an organization. This program requires 19 credit hours of study.

The MS degree with a concentration in general management is designed for individuals whose careers would be enhanced by learning the foundations of successful management. The program requires completion of 12 classes. Nine of these are required core classes that cover the principles of finance, accounting, marketing, operations, information systems, managerial economics, and data-driven managerial decision making. The three remaining classes are electives that students can choose according to their interests. A student pursuing the MS degree with a concentration in general management on a full-time basis completes the program in four quarters. A variety of part-time scheduling opportunities is possible.

The MS in business administration in marketing is designed to equip students with the skills and experience necessary to excel in marketing jobs in a compact, highly focused program. Students are likely to take a job related to one of the program’s three main emphases: advertising, marketing research, and sales. The ideal candidate for the Simon School MS program is someone with high energy who is excited about the prospect of learning advanced skills in a compact time frame and subsequently pursuing a successful marketing career. Applicants should have taken some mathematics and/or statistics as undergraduates and be ready for advanced statistical training in the program.

The MS in business administration in medical management’s objective is to provide physicians and medical professionals with management tools to enable them to independently manage their health care organizations. The part-time medical management master’s program is specifically designed to accommodate the busy schedules of physicians and other medical professionals. The program can be completed in one calendar year, with an in-class time commitment of one night per week and one weekend per month (with, of course, additional preparation and work outside of class). Full-time study is offered for recent undergraduates who are seeking professional roles in a health sector organization.
Master of Science in Finance
The MS in finance degree is available as follows:

Students who have already earned an MBA with a general management or non-finance focus and need additional training in the finance area and/or are considering a career change.

Students with a completed bachelor degree and a demonstrated quantitative aptitude. There are two additional graduate courses required for students who do not already hold an MBA degree.

The degree is offered on a full-time or part-time basis and classes are taught by a faculty internationally known for financial expertise. Full-time students complete the program in 9 to 11 months depending on whether the candidate already holds an MBA degree.

Master of Science in Accountancy
The Master of Science in accountancy program is designed for students seeking to pursue Certified Public Accounting (CPA) licensure. New York State, as well as most other states, has adopted a 150-credit-hour educational requirement, which can be satisfied with a combination of undergraduate and graduate courses. The MS in accountancy program can be completed in one academic year of full-time study. It is also offered on a part-time basis.

For more information about the Simon School’s MS programs, visit us online at www.simon.rochester.edu/.

Executive MBA Programs
The mission of the Simon School’s Executive MBA program is to maximize the benefits of a general management MBA for mid-career professionals. This program consists of two academic years of intensive MBA classes. Classes are offered on a Friday-Saturday schedule so that students may continue to work full time. The integrated sequence of courses leads to a fully accredited Master of Business Administration from the University of Rochester. An executive MBA program has been established with a European partner institution. Designed for European managers, the program consists of 18 months of study, including a summer term in Rochester. The course of study is equivalent to the Rochester executive program and is taught by Simon School faculty along with European scholars.

Admission to the Executive MBA Program is based on application and interview.

For additional information or to request a catalog and application, please visit us online at www.simon.rochester.edu/emba.

Joint Degree Programs
MBA-MPH
The Simon School offers a three-year program in conjunction with the School of Medicine and Dentistry. Courses are taken both at the Simon School and at the Medical Center in the Department of Community and Preventive Medicine. For further information, consult the current issue of the Simon School Information Guide or contact the MBA/MS Admissions Office at the Simon School.

MD-MBA
The Simon School, in conjunction with the University’s School of Medicine and Dentistry, offers a five-year program in which students can earn both the Master of Business Administration and the Doctor of Medicine degrees. Interested students may obtain more information from the Office of the Associate Dean at the Medical School or the MBA/MS Admissions Office at the Simon School.

For more information, visit us online at www.simon.rochester.edu/.

PhD Program
The Simon School offers a PhD program for students who are interested in research and teaching careers. The program is highly analytical in its orientation and, while real-world applications are emphasized, students receive substantial training in theory and quantitative methods. Program graduates have excellent employment opportunities in academe and other research institutions.

All students start with the first year, called the core, building a firm foundation of mathematics, statistics, and economics. While the majority of the courses are taken in common by all the incoming students, there is some specialization. This specialization becomes more intense in the second year when the students concentrate on their major and minor fields of study. The “core” exams, given in June of the first year, serve as a key for early assessment and are based solely on the material covered in the core courses. They are designed to determine whether the student has learned enough of the basic material to make continuation in the program advisable.

A first-year research paper is required in the fall of the second year. This paper is designed to get students thinking about research early in their academic careers, which enhances the process of choosing a thesis topic.

During the second year of the program, students concentrate their study in two chosen fields of specialization, a major and a minor. The fields offered are accounting, applied economics, applied statistics, competitive and organizational strategy, computers and information systems, finance, macroeconomics, management science, marketing, and operations management. Most fields are defined by the material covered in seven to nine advanced courses and most students choose to take these courses. Qualifying examinations in these fields are given in the summer and fall following the second year of study, and students complete work on an original research paper, which also must be presented by the fall of the third year.

Early in the third year, students are evaluated for admission to candidacy. The candidacy decision involves an evaluation of the students’ overall academic performance. Recommendations for admission to candidacy by the faculty in the students’ major area imply a willingness to supervise their dissertations. At this point, students move on to their research for the dissertation.

When students have made enough progress on the thesis to define the problem and to state how the remainder of the research will proceed, a thesis proposal seminar is scheduled. In this seminar, students describe future research plans to interested faculty and to other PhD candidates. The faculty then evaluate the proposal and decide whether or not it is acceptable. When
the research described in the approved proposal is completed satisfactorily and successfully defended in another seminar, students are awarded the PhD degree.

**PhD Admission and Financial Aid**

No particular undergraduate major is required for admission to the PhD program, but some training in mathematics (at least a year of calculus) is essential. Many students have undergraduate degrees in mathematics, engineering, or economics-based majors. All students are required to spend the months of July and August before their first year honing mathematic and statistical skills in preparation for first-year coursework. Financial aid is available for these two months.

Applicants to the program must take either the Graduate Management Admission Test or the Graduate Record Examination. Their scores on the test, academic records, and letters of recommendation are all considered carefully by the PhD committee.

Most students who are admitted to the program receive financial assistance. In the first year of study, this financial aid is in the form of a fellowship plus a tuition scholarship. The generous fellowship allows first-year students to devote full time to studies. Advanced students typically receive a combination of a fellowship, tuition scholarship, and a teaching or research assistantship.

The application deadline for all applicants is January 15. For more information, see the Simon School website at www.simon.rochester.edu/programs/phd/index.aspx.

**Courses of Graduate Instruction**

A complete listing of courses and course descriptions can be found in the current issue of *Simon Management Programs* (MBA or MS) or the EMBA Program catalog, which may be obtained from the Admissions Office, William E. Simon Graduate School of Business Administration, Schlegel Hall, University of Rochester, P.O. Box 270107, Rochester, New York 14627-0107; (585) 275-3533 or (585) 275-2959 (PhD).
Margaret Warner Graduate School of Education and Human Development

Administrative Officers

Raffaella Borasi, Ph.D
Dean
Brian Brent, Ph.D
Associate Dean of Graduate Studies
Logan Hazen, Ed.D
Director of Student Services

Faculty

PROFESSOR

Raffaella Borasi, PhD (SUNY, Buffalo)
Frederica Warner Professor of Education
Brian Brent, PhD (Cornell)
Earl B. Taylor Professor of Education
Randall R. Curren, PhD (Pittsburgh)
Professor of Philosophy and of Education
Lucia A. French, PhD (Illinois)
Earl B. Taylor Professor of Education
Frederick C. Jefferson, Jr., EdD (Massachusetts, Amherst)
Professor Emeritus of Education
Howard Kirschenbaum, EdD (Temple)
Professor Emeritus of Education
Joanne Larson, PhD (California, Los Angeles)
Michael W. Scandling Professor of Education
Richard Ryan, PhD (Rochester)
Professor of Psychology, of Psychiatry, and of Education
Tyll van Geel, EdD (Harvard), JD (Northwestern)
Professor Emeritus of Education

ASSOCIATE PROFESSOR

Nancy Ares, PhD (Auburn)
Associate Professor of Education
Mary Jane Curry, PhD (Wisconsin)
Associate Professor of Education

Jeffrey Choppin, PhD (Wisconsin)
Associate Professor of Education
Kathryn Douthit, PhD (Rochester)
Associate Professor of Education
Kara Finnigan, PhD (Wisconsin)
Associate Professor of Education
Judith Fonzi, PhD (Rochester)
Associate Professor of Education (clinical)
Doug Giuffrida, PhD (Syracuse)
Associate Professor of Education
David Hursh, PhD (Wisconsin)
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April Luchmann, PhD (Michigan)
Associate Professor of Education
Andre Marquis, PhD (North Texas)
Associate Professor of Education
Bonnie Rubenstein, EdD (Rochester)
Associate Professor (clinical)
Dena Swanson, PhD (Emory)
Associate Professor of Education
Stephen Uebbing, EdD (SUNY, Buffalo)
Associate Professor of Education (clinical)

ASSISTANT PROFESSOR

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*Cindy Callard, EdD (Rochester)
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Assistant Professor of Education
Logan Hazen, EdD (Oregon State)
Assistant Professor of Education (clinical)
Susan Hetherington, MS (Rochester)
Assistant Professor of Pediatrics and of Education (clinical)

* Part-time
General Information

The Margaret Warner Graduate School of Education and Human Development offers programs leading to the Doctor of Philosophy (PhD), Doctor of Education (EdD), Master of Science (MS), and Master of Arts in Teaching (MAT) degrees, as well as a several non-degree programs leading to professional certifications.

For all graduate programs, admission to the Warner School is made through the Admission and Financial Aid Committee. Admission decisions for master’s and EdD applicants are made at specific times during four application cycles, with deadlines in October, January, March, and June; PhD applications are re-reviewed in the January cycle only.

Admission to all programs is based on the applicant’s record of academic achievement, letters of recommendation, writing sample, personal interviews when required, and the fit of research and career goals and professional interests with the Warner School’s research programs and resources. Transcripts of higher education coursework, both graduate and undergraduate, should be forwarded directly from all institutions attended. The Test of English as a Foreign Language (TOEFL) or the academic module of the International English Language Testing System (IELTS) is required for applicants who are nonnative English speakers. In some cases, this requirement will be waived for international students who can otherwise demonstrate English proficiency.

Applicants who wish to be considered for financial aid in the form of an assistantship and/or scholarship should indicate that in their application. Additional information about applications and financial aid can be obtained from the Admissions Office, (585) 275-3950 or admissions@warner.rochester.edu.

All program requirements and course descriptions in this bulletin are subject to change. For the most up-to-date program requirements and course descriptions, please visit our website at www.warner.rochester.edu.

Doctoral Programs

The Warner School offers two types of doctoral programs: Doctor of Philosophy (PhD) and Doctor of Education (EdD). The PhD program is designed specifically to prepare students for careers devoted to research and scholarship, particularly in a university environment. The EdD is designed to enable outstanding education professionals to apply research to their field of practice.

Both degree programs require 90 credit hours (96 for students specializing in counseling). Students who have already undertaken relevant graduate-level coursework may be allowed to transfer it to their program (up to a limit of 30 credits for PhD students and 36 credits for EdD students) provided that: (1) the course(s) in question was taken within 10 years of the date of matriculation; (2) a grade of “B” or higher was earned; (3) they are approved by the student’s advisor, program chair, and associate dean of graduate studies. If the courses were completed more than 10 years ago, students are required to submit a curriculum vitae and written narrative, describing how they have remained involved in their field of study, to help the advisor, chair, and associate dean determine whether exceptions could be made. Transfer credit decisions are made at the time of approving each student’s program of study. Courses taken at institutions other than the University of Rochester after matriculation into the doctoral program may not be used toward the doctoral degree.

In addition to coursework, doctoral students also need to successfully complete a set of experiences. First, after having taken at least 18 credits in the program, all doctoral students must submit a portfolio for review. The portfolio review is evaluative, but the feedback offered by faculty is also intended to nurture developing research expertise and intellectual and professional development. After passing the portfolio assessment and having completed most of the coursework for the degree, all doctoral students are then expected to undertake an individualized comprehensive examination. Specific requirements for the comprehensive exam vary by program area. Finally, all doctoral programs culminate in the completion of a doctoral dissertation.

Advancement to candidacy for the PhD or EdD degree occurs upon successful defense of the dissertation proposal. The degree is awarded after completion of all degree requirements, and upon successful oral defense and acceptance of the doctoral dissertation.
All work for the doctoral degree, including the final oral examination on the dissertation, must be completed within seven years from the date of initial registration. Students with 30–36 credit hours accepted in the doctoral program must complete all work within six years from the date of matriculation in the doctoral program. Students who for good reason have been unable to complete a program within the above stated limits may, upon recommendation by the faculty advisor and the program chair, petition the associate dean of graduate studies for an extension of time. Such extension, if granted, will be of limited duration and may be re-approved at least biannually, and it may require additional coursework.

Students must maintain continuous registration through the program. Full-time students must register for at least 12 credit hours, or nine credit hours with an assistantship, during every fall and spring semester (excluding summer session) until the degree program is completed. Continuous registration for part-time students means registration for a total of nine credit hours every academic year sequence of summer-fall-spring until the degree program is completed. If a student does not register for coursework during any fall or spring semester, that student must register for continuation of enrollment for that fall or spring semester. Students have to either register for courses or for Continuation of Enrollment every fall and spring semester until the program degree is completed.

**PhD in Education**

The Warner School offers several areas of study within the PhD in Education. Students may concentrate in one of the following areas: Counseling and Counselor Education; Educational Policy and Theory; Higher Education; Human Development in Educational Contexts; and Teaching, Curriculum, and Change. PhD dissertations should provide an original and scholarly contribution to research in the student’s major field. A minimum of one year of full-time residency is required of all PhD students.

**EdD in Education**

The EdD degree is available with the following areas of concentration: K–12 School Administration; Higher Education; Teaching and Curriculum; Mental Health Counseling and Supervision; Counseling; and Human Development. There is no minimum residency requirement for this program, although students are strongly encouraged to make arrangements so that they can devote the necessary time to their dissertation research.

Students completing the EdD in Mental Health Counseling and Supervision are automatically licensure-eligible for the new New York State License in Mental Health Counseling.

The Warner School offers an accelerated option for EdD students who are experienced practitioners in their field of specialization and want to pursue the degree part time while holding a professional job in the same field, with a specially structured and supported yearlong dissertation cohort process. This option makes it possible for eligible students to earn a doctorate in education in as few as three years on a part-time basis for most EdD programs. Additional admission criteria and program requirements must be met by students choosing the accelerated option.

**Certificate of Advanced Study**

Under certain circumstances, the Warner School awards a Certificate of Advanced Study. The certificate is not a degree, nor does it constitute a legally recognized credential. It does, however, formally attest to the successful completion of 60 credits of graduate study.

**Master’s Programs**

The Warner School is committed to excellence in pre-service and in-service preparation of education professionals at the master’s level. It maintains programs that prepare students to undertake a wide variety of professional roles in schools and other educational settings. Several of these programs also enable students to satisfy all the academic requirements needed to obtain initial and/or professional certification from New York State or become eligible for licensure. All these programs combine strong emphasis on professional excellence with the University’s commitment to sound scholarship and are nationally accredited by NCATE and/or CACREP.

All master’s degrees require completion of at least 30 credit hours of coursework, although many MS degree programs require additional credit hours (as indicated for each program listed in this section).

Transfer credit pertains to coursework from another institution or another school or college within the University of Rochester that is completed before the student matriculates into a degree program at the Warner School. Retroactive credit pertains to coursework completed at the Warner School prior to matriculation into a degree program. No more than 10 credit hours may be accepted as transfer credit into a master’s degree. It is possible that a combination of transfer and retroactive credit may exceed 10 credit hours. Transfer credit and retroactive credit are permitted only when they meet the following criteria: (1) must have been taken within five years of the date of matriculation, (2) must have received a grade of B or higher, and (3) must meet the approval of the faculty advisor, program chair, and the associate dean of graduate studies. Courses taken at institutions other than the University of Rochester after matriculation in the master’s degree program may not be used toward the master’s degree.

The total time limit for completing a master’s degree is five years. Requests for extension of this deadline must be submitted in writing to the associate dean of graduate studies. Such extensions, if granted, will be of limited duration and may require additional coursework.

Students may pursue the MS degree on a full-time or part-time basis. In cases that require a field placement (student teaching, practicum, or internship), however, it may be necessary to spend one or two semesters in full-time residence. Policies regarding conditions for fulfillment of field placement responsibilities vary from program to program. All master’s programs require a culminating assessment, although the nature of this assessment varies across programs (master’s essay, thesis, portfolio, or comprehensive exam). Students must maintain continuous registration throughout the program. Continuous registration for part-time students means registration for a total of nine credit hours every academic year sequence of summer-fall-spring until the degree program is completed. If a student does not register for coursework during any fall or spring semester, that student must register for continuation of enrollment for that fall or
spring semester. Students have to either register for courses or for Continuation of Enrollment every fall and spring semester until the degree program is completed.

Prospective applicants are encouraged to visit our Web site and contact the Warner School’s Admissions Office for specific details about requirements. The most up-to-date program requirements and course descriptions are available on the Warner website at www.warner.rochester.edu.

Programs Preparing Entry-Level Teachers
The Warner School offers a variety of master’s programs and options that lead to New York State Initial Teaching Certification in specific subject matters and/or grade levels. These programs also satisfy all the academic requirements for professional teaching certificates in the same area and are nationally accredited (NCATE).

MS in Education, leading to NYS teaching certification in one of the following areas:
- Early Childhood (birth to grade 2) 45 credits
- Childhood (grades 1–6) 45 credits
- Middle Childhood* (grades 3–9) 39 credits
- Adolescence* (grades 7–12) 39 credits
- Middle Childhood and Adolescence* (grades 5–12) 42 credits
- Teaching English to Students of Other Languages (grades K–12) 39 credits
- Teaching Students with Disabilities (grades 7–12 as generalist) 45 credits
- Students can do dual certification in inclusion and early childhood or childhood education.

MAT in (Subject Area),* leading to NYS teaching certification in Adolescence (grades 7–12) 51 credits

Additional Teaching Certifications
Students who meet the prerequisites and are interested in dual certification in one of the above areas and Teaching Students with Disabilities can do so by adding an additional 12 credit hours of required courses in disability and inclusion to any of the previous programs and conducting their internships in inclusive settings. Students interested in specializing in urban education can apply to the Urban Teaching and Leadership Program, which includes additional experiences and coursework focusing on teaching in urban settings.

Programs for Current Teachers
The Warner School also offers a variety of options to initially certified teachers interested in pursuing professional certification through a master’s degree and/or seeking an additional certification.

MS in Education (same area of specialization) 30 credits

MS in Education (leading to NYS certification at a new grade level or in a different specialization) 35 credits

MAT in (Subject Area of Specialization) 30 credits

MS in Inclusive Education (also satisfying all requirements for NYS certification in Teaching Students with Disabilities in the same area of specialization) 30–35 credits

MS in Reading and Literacies (also satisfying all requirements for NYS certification in Teaching Literacy) 36 credits

Programs Preparing for Entry-Level Positions in Counseling
There are different master’s programs available for counselor preparation leading to the following specializations:

School Counseling, leading to NYS Provisional Certification in School Counseling: 48 credits

School Counseling, leading to NYS Provisional Certification in School Counseling and the required coursework to later attain NYS Permanent Certification (with concentrations in School Community, Disability, Diversity, or Leadership): 60 credits

Community Mental Health Counseling,† leading to NYS licensure—a licensure exam and 3,000 post-master’s hours of supervised experience are also required for licensure: 60 credits

Programs Preparing Entry-Level K–12 School Administrators
Experienced teachers or counselors interested in assuming administrative positions in New York State are required to obtain a School Building Leadership (SBL) certification for positions at the building level, or School District Leadership (SDL) certification for positions at the district level. The following degree programs have been designed to fulfill all coursework and internship requirements for each or both of these certifications.

MS in Educational Administration, leading to SBL certification: 36 credits

MS in Educational Administration, leading to SDL certification: 60 credits

Students interested in specializing in Catholic, private, and/or independent schools can pursue additional seminars and experiences to prepare for these contexts.

Master’s Programs without Certification
The Warner School also offers a number of master’s degrees for students interested in obtaining an introduction to various fields of education, either to increase their qualifications for professions that do not require a specific certification, or to prepare to enter a doctoral degree program.

MS in Human Development (with concentrations in Early Childhood, Family Studies, Developmental Differences, Gerontology, or Research/Program Evaluation) 30 credits

MS in Teaching and Curriculum 30 credits

* These programs lead to NYS Teaching Certification in one or more of the following subjects: English, foreign languages (French, Spanish, German, Italian, and/or Chinese), Latin, mathematics, science (biology, chemistry, physics, and/or earth science), and social studies.

† For those who are interested in working with select special populations, we recommend that you tailor electives and internships to further those interests. Students can choose electives and internships in the following license-eligible areas of focus: Gerontological Counseling and College Counseling.
Non-Degree Programs

Students who already hold a master's degree but are seeking additional NYS certifications can also pursue their goals by enrolling in one of the Warner School's non-degree programs leading to a specific certification (registered with the NYS Education Department). The number of credit hours necessary to complete each of these certification programs depends on each student's previous background.

Non-Degree Programs, Leading to Additional Teaching Certification in the Following Areas

- Early Childhood (birth to grade 2)
- Childhood (grades 1–6)
- Middle Childhood* (grades 5–9)
- Adolescence* (grades 7–12)
- Teaching Students with Disabilities (at one of the three grade levels: birth to grade 2, grades 1–6, or grades 7–12)
- Teaching Students with Severe and/or Multiple Disabilities (NYS Annotation)
- Reading and Literacies (birth to grade 6 or grades 5–12)
- Teaching English to Students of Other Languages (grades K–12)

Non-Degree Programs Leading to Administrative Certification in the Following Areas

- School Building Leadership (24 credits)
- School Building and School District Leadership (27 credits—assuming that additional 36 graduate credits have been previously completed)
- School Building Leadership (24 credits—with specialization in Catholic and other private schools (24 credits)

Non-Degree Programs Leading to NYS Professional (Permanent) Certification in School Counseling (12 additional credits)

Non-Degree Programs Leading to Warner Certificates

The Warner School also offers the following non-degree programs consisting of a series of courses and possibly internships that lead to internal Warner certificates:

- MS in Educational Administration (with concentrations in K–12 School Administration, General Higher Education Administration, or Higher Education Student Affairs Administration) 36 credits
- MS in Educational Policy 30 credits
- MS in Health Professions Education (offered through the Warner School in collaboration with the School of Nursing and the School of Medicine and Dentistry) 30 credits

Urban Teaching and Leadership (12 credits), a three-year sequence including two courses and six one-credit seminars for certified teachers interested in urban settings.

Program Evaluation, a post-master's series of courses and internships to prepare program evaluators (may also be earned as part of the accelerated EdD programs in Educational Leadership).

Autism Spectrum Disorders and Applied Behavior Analysis, a four-course plus internship sequence offered through the Warner School in collaboration with the Strong Center for Developmental Disabilities' Autism Program.

Options for Undergraduates

The Warner School offers several exciting programs designed exclusively for College undergraduates, including:

Teacher Preparation

Due to changes in the New York State teacher certification requirements, the Warner School no longer has a teacher education program at the bachelor's level. Undergraduates interested in a career in teaching are encouraged to take courses at the Warner School and seek classroom experience to help get a head start on a graduate program in their area of interest. Starting teacher education coursework as an undergraduate provides students with the opportunity to explore and better understand the teaching profession and can allow for the completion of a master's degree and New York State Teaching Certification in one additional year of study. In most cases, the basic teacher preparation program (leading to NYS Initial Teaching Certification and fulfilling all the academic requirements for Professional Teaching Certification) is offered through 15 months of post-graduate study and is offered at the early childhood and elementary levels and in English, mathematics, Latin, French, Spanish, German, Italian, Chinese, biology, chemistry, physics, earth science, and social studies at the secondary level. Programs for those interested in Teaching English to Speakers of Other Languages (grades K–12), Teaching Students with Disabilities (birth to grade 2, grades 1–6, and grades 7–12), Teaching Students with Severe and/or Multiple Disabilities (NYS Annotation), and Reading and Literacies (at either birth to grade 6 or grades 5–12) are also available.

Students considering a career in teaching are also encouraged to complete all subject area requirements at the undergraduate level. New York State specifies the number of hours in various subjects required for certification (usually about 10 undergraduate credits in the subject of specialization, but there are some variations so make sure you check), including at least one college-level semester in a foreign language (ASL is also acceptable). Consult with a counselor in the Warner School Admissions Office, (585) 275-3950 or admissions@warner.rochester.edu, for exact requirements for the specialization you are considering.

* These programs lead to NYS Teaching Certification in one or more of the following subjects: English, foreign languages (French, Spanish, German, Italian, and/or Chinese), Latin, mathematics, science (biology, chemistry, physics, and/or earth science), and social studies.
Robert Noyce Scholarships
The Warner School offers a new scholarship opportunity for science, technology, engineering, and mathematics (STEM) majors to become effective science and mathematics teachers and to expand the number of highly qualified teachers serving high-need school districts. Noyce scholars attend the Warner School’s teacher preparation program effectively tuition free. The program, which awards scholarships to up to eight students per academic year (through 2014) who have a degree in math or science, provides an incentive for talented undergraduates to work as math and science teachers in high-need school districts. All Noyce Scholars participate in Warner’s high-quality, innovative teacher preparation programs leading to teaching certification in mathematics, biology, chemistry, physics, or earth science. Noyce scholars commit to teach in a high-need school for at least two years following their graduation. If they fail to meet this teaching service requirement, scholarship recipients must repay to the University the full monetary value of their Noyce award.

Project Press Scholarships
The Warner School offers scholarships to prepare highly qualified pre-service and in-service teachers to work with children with significant disabilities in a variety of settings, including high-need and low-performing schools. The program, known as Preparing and Retaining Highly Qualified Educators of Students with Significant Disabilities—or Project PRESS—will award 32 scholarships over the next five years (through 2016) to aspiring and current teachers to serve and meet the needs of students with significant disabilities. Scholarship recipients will enroll tuition free into the Warner School’s innovative inclusive and special education program at the elementary/childhood (grades 1–6) or secondary (grades 7–12) levels leading to a master’s degree and New York State certification in Teaching Students with Disabilities and/or the NYS annotation for Teaching Students with Severe and/or Multiple Disabilities. Upon completion of the program, graduates make a commitment to provide special education or related services to children with disabilities for at least two years for every year the scholarship is received.

Fifth Year in Teaching Scholarship/Urban Teaching and Leadership Program
The University of Rochester recognizes the critical need for teachers of traditionally marginalized students and through the Warner School of Education offers a unique program to encourage its undergraduates from diverse backgrounds and subject areas experiencing shortages to enter the teaching profession and be prepared to teach in urban settings. The Fifth Year in Teaching Scholarship provides a limited number of full-tuition awards for graduate study at the Warner School during their senior year to become teachers in urban settings. Successful applicants are accepted into the Urban Teaching and Leadership Program (UTL), where they will complete a master’s program in teaching and curriculum, leading to either NYS Initial or Professional Certification, and two years of teaching in an urban school. In addition to their coursework and field requirements for certification, UTL students participate in monthly seminars that focus on critical approaches to teaching in urban settings. The goal of the UTL Program is to prepare talented classroom teachers who are committed to social change and who will address the inequalities confronting public education in America’s cities. Through a unique partnership between the Warner School and the Rochester City School District, the UTL Program equips urban educators to combine a passion for social justice with innovative teaching practices to improve the quality of education for all youth.

The Fifth Year in Teaching Scholarship has been designed to help the Warner School address the needs of urban schools by encouraging qualified University of Rochester undergraduates to become skilled teachers in urban areas. Recipients of the award will include individuals who are able to increase diversity of the urban teacher population or increase the number of certified teachers in specializations where there are the highest shortages in the Rochester area.

These scholarships cover full tuition as well as on-campus room and board for students who prove financial need (some restrictions apply). Upon acceptance of the Fifth Year in Teaching Scholarship, candidates make a commitment to successfully obtain their master’s degree from the Warner School, become certified to teach by the NYS Department of Education, and to teach in an urban school for two complete academic years following graduation, and complete all UTL post-graduation coursework and requirements. Please visit www.warner.rochester.edu/programs/utl/ for more details on eligibility criteria.

Health Professions Education
A new Master of Science (MS) degree in health professions education, an interdisciplinary program designed by and offered through a collaboration of the Warner School, the School of Nursing, and the School of Medicine and Dentistry at the University of Rochester, is now offered for health care professionals, including nurses, doctors, physical therapists, and nutritionists who are in health care education and those who are interested in moving into such positions and who seek formal training in education. The interdisciplinary program provides theoretical and practical preparation for teaching and related skills to health care professions.

Higher Education
The Warner School’s master’s programs in higher education prepare thoughtful administrators and researchers for positions at postsecondary institutions, in government, and in many organizations that work with and for colleges and universities. The master’s with a concentration in student affairs administration offers students an opportunity to combine practical leadership experience in student affairs with a dynamic academic program. The master’s with a concentration in general higher education administration provides this same energy with a focus on administration and governance. At the doctoral level, the Doctor of Education (EdD) in educational administration is offered with a concentration in higher education and the Doctor of Philosophy (PhD) is offered with a concentration in higher education.
Educational Policy
A Master of Science (MS) degree in educational policy is now offered for those interested in assuming policy positions or planning to pursue doctoral study in areas related to educational policy. The master’s program enables students who want to have a meaningful impact on schools, school systems, and the lives of children to influence policy, design, implementation, and evaluation and serve as a catalyst for improving America’s schools. The 30-credit program makes it possible for candidates to receive their degree in one year of full-time study (if starting in the summer or taking a few courses as an undergraduate). Graduates acquire a deep understanding of our education system and education reform nationwide and are prepared to work as policy analysts, educational policymakers, and researchers at government agencies, nonprofit organizations, and districts, where they will help formulate new strategies and evaluate their effect. At the doctoral level, the Doctor of Philosophy (PhD) in education is offered with a concentration in educational policy and theory. This program is geared toward students who have an advanced degree in policy, political science, economics, sociology, or a related area and are interested in a career in policy research and analysis.

The Combined Undergraduate and Graduate Programs in Counseling and Human Development
The combined undergraduate and graduate programs in counseling and human development offer an opportunity to qualified University of Rochester undergraduate students to begin graduate study toward the Master of Science (MS) degree during their senior year. The master’s program in human development can be completed after one year of postgraduate study. The school counseling program, which leads to New York State certification as a school counselor, takes about two years of postgraduate study. The program in community mental health counseling, which leads to New York State licensure in mental health counseling, also can be completed in two additional years.

In the first year of a combined program, students who are in their senior year and are simultaneously enrolled in the master’s degree program finish their undergraduate work and receive the bachelor’s degree in their undergraduate concentration at the end of the senior year. In the human development program, they must complete a minimum of 15 credits hours of graduate coursework in their senior year, which can also be counted toward their undergraduate degree, and then an additional 30 credits of graduate coursework in human development (for a total of 45 credit hours). For the counseling programs, students in the 48-credit-hour school counseling program may take 9 credit hours of graduate coursework during their senior year, and students in the 60-credit-hour school counseling program and the community mental health counseling program may take up to 21 credit hours during their senior year. A master’s capstone project and, in the case of the counseling programs, internships are required.

Applications for the combined programs must be completed no later than spring semester of the junior year. Admission requires that the student’s undergraduate concentration will be completed by the end of the junior year, or assurance from the concentration department that the requirements for the bachelor’s degree will be met by the end of the senior year. Early inquiry is encouraged, especially from sophomores and first-semester juniors.

The Guaranteed Rochester Accelerated Degree in Education
The Guaranteed Rochester Accelerated Degree in Education (GRADE) is a five-year BA/BS + MS education program for undergraduate students admitted to the University of Rochester who are interested in becoming educators (six years if pursuing a specialization in counseling). GRADE students enter the University with an assurance of admission to the Warner School (provided that they meet the prerequisites for their selected area of specialization by the time they complete their undergraduate degree) with the Steven Harrison quarter-tuition scholarship for the duration of the program. The program is designed to offer students a quality liberal arts education while also preparing them to become educators.

SCHOOL-WIDE COURSES
All the courses below carry three graduate credit hours, unless otherwise noted.

With rare exceptions, courses are offered in the evenings during the academic year. In addition, several courses are also offered during the summer. For a complete listing of courses, visit the Warner website at www.warner.rochester.edu.

ED 406. Master’s Research Methods
ED 410. History of American Education
ED 411. Philosophy of Education
ED 412. Sociology of Education
EDU 416. Conflict Management in Schools and Universities
ED 421. Reform in Public Schools
ED 428. Ethics and Education
ED 429. Theories of Human Development
ED 432. Professional Writing and Communications
ED 435. Critical Thinking and Professional Practice
ED 438. Sociology of School Organizations
ED 439. Policy Analysis in Education
ED 440, 441, 442, 443, 444, and 445. Urban Teaching and Leadership Seminars
Credit—one hour
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<tr>
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<td>EDU 446</td>
<td>Entrepreneurial Skills for Educators</td>
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<tr>
<td>EDU 447</td>
<td>Grant Writing and Other Funding Strategies for Educators</td>
</tr>
<tr>
<td>EDU 455</td>
<td>Policy and Practice in Developmental Differences</td>
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<tr>
<td>ED 461</td>
<td>The Politics of Education</td>
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<tr>
<td>ED 468</td>
<td>Leadership in Urban Schools</td>
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<tr>
<td>ED 470</td>
<td>Leading Effective Program Design</td>
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<tr>
<td>ED 481</td>
<td>School, Family, and Community Relations</td>
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<tr>
<td>ED 483</td>
<td>Communication and Counseling Skills for Teachers, Administrators, and Other Helping Professionals</td>
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<td>EDU 497</td>
<td>Teaching and Learning in Higher Education</td>
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<td>ED 504</td>
<td>Quantitative Research Methods</td>
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<td>ED 505</td>
<td>Advanced Quantitative Research Methods</td>
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<tr>
<td>ED 506</td>
<td>Concepts and Issues in Social Science Research</td>
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<tr>
<td>ED 507</td>
<td>Qualitative Research Methods</td>
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<tr>
<td>ED 513</td>
<td>Academic Writing for Educators</td>
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<tr>
<td>ED 515</td>
<td>Writing for Scholarly Publication in the Social Sciences</td>
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<tr>
<td>ED 516</td>
<td>Designing and Evaluating Professional Development</td>
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<tr>
<td>ED 517</td>
<td>Schooling and Social Justice</td>
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<tr>
<td>ED 520</td>
<td>Program Evaluation</td>
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<tr>
<td>ED 521</td>
<td>Advanced Program Evaluation</td>
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<tr>
<td>ED 523</td>
<td>Mixed Research Methods</td>
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<tr>
<td>ED 524</td>
<td>Survey Design</td>
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<tr>
<td>ED 525</td>
<td>Interview and Focus Group Techniques</td>
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<td>ED 527</td>
<td>Advanced Qualitative Research Methods</td>
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<tr>
<td>ED 528</td>
<td>Using Quantitative Data Analysis Software</td>
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<tr>
<td>ED 529</td>
<td>Using Qualitative Data Analysis Software</td>
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<tr>
<td>ED 531</td>
<td>Case Study Design and Analysis</td>
</tr>
<tr>
<td>ED 533</td>
<td>Research Strategies Series</td>
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<tr>
<td>ED 581</td>
<td>Discourse Analysis</td>
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**TEACHING AND CURRICULUM COURSES**

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<tr>
<th>Course Code</th>
<th>Course Title</th>
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</thead>
<tbody>
<tr>
<td>ED 400/400A</td>
<td>Topics in Teaching and Schooling</td>
</tr>
<tr>
<td>ED 403</td>
<td>Disability and Early Childhood</td>
</tr>
<tr>
<td>ED 404</td>
<td>Teaching, Curriculum, and Change</td>
</tr>
<tr>
<td>ED 405</td>
<td>Assessment in Instructional Contexts</td>
</tr>
<tr>
<td>ED 407</td>
<td>Development, Learning, and Teaching for Children Ages 3 to 5</td>
</tr>
<tr>
<td>ED 408</td>
<td>Development, Learning, and Teaching for Children Ages Birth to 3</td>
</tr>
<tr>
<td>ED 409</td>
<td>Language and Literacy in Education</td>
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<tr>
<td>ED 415</td>
<td>Adolescent Development and Youth Culture (ages 10 to 20)</td>
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<tr>
<td>EDU 427</td>
<td>Theory and Practice in Teaching and Learning Literacy in Elementary School</td>
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<tr>
<td>EDU 428</td>
<td>Theory and Practice in Teaching and Learning Social Studies in Elementary School</td>
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<td>EDU 429</td>
<td>Theory and Practice in Teaching and Learning Science in Elementary School</td>
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<td>EDU 430</td>
<td>Theory and Practice in Teaching and Learning Mathematics in Elementary School</td>
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<td>EDU 431</td>
<td>Theory and Practice in Teaching and Learning English</td>
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<tr>
<td>EDU 432</td>
<td>Theory and Practice in Teaching and Learning Social Studies</td>
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<td>EDU 433</td>
<td>Integrating Social Studies and Literacy</td>
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<td>EDU 434</td>
<td>Theory and Practice in Teaching and Learning Science</td>
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<tr>
<td>EDU 435</td>
<td>Theory and Practice in Teaching and Learning Foreign Languages and ESOL (English to Speakers of Other Languages)</td>
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<tr>
<td>EDU 436</td>
<td>Theory and Practice in Teaching and Learning Mathematics</td>
</tr>
<tr>
<td>EDU 440</td>
<td>Children’s Literature and Literacy Learning</td>
</tr>
</tbody>
</table>
EDU 442. Race, Class, Gender, and Disability in American Education

EDU 443. Implementing Innovation in English Education

EDU 444. Implementing Innovation in Mathematics Education

ED 446. Collaborative Teaching Partnerships in Inclusive Classrooms

ED 447. Disability and Schools

EDU 448. Implementing Innovation in Science Education

ED 451. Teaching and Learning in Inclusive Classrooms

ED 452A/452B/452C. Instructional Strategies for Inclusive Classrooms  
Credit—one hour each

ED 453. Principles, Methods, and Applications in Applied Behavior Analysis I

ED 457. Autism Spectrum Disorders: Characteristics and Educational Issues

ED 458. Principles, Methods, and Applications in Applied Behavior Analysis II

ED 459/460. Practicum in Applied Behavior Analysis and Autism Spectrum Disorders I/II

EDU 462. Implementing Innovation in Social Studies Education

EDU 463. Implementing Innovation in Foreign Languages and ESOL Education

EDU 464. Child Development and Learning in Context  
(ages 5 to 12)

EDU 467. Language, Literacy, and Cognitive Development

EDU 475. Early Intervention for Children with Disabilities  
(ages 3 to 5)

EDU 476. Early Intervention for Children with Disabilities  
(ages birth to 3)

EDU 477. Integrating Curriculum in Early Childhood

ED 480. Second Language Acquisition and Bilingualism

EDU 480/480A. Theory and Practice in Teaching and Learning the Arts in Elementary School

EDU 481. Integrating English and Technology

EDU 482. Integrating Mathematics and Literacy

EDU 483. Integrating Mathematics and Technology

EDU 486. Integrating Science and Technology

EDU 487. Integrating Science and Literacy

ED 489. Implementing Curriculum Reform in Mathematics

EDU 495. Theory and Practice for Reading Professionals

EDU 498. Literacy Learning as Social Practice

EDU 499. Integrating Social Studies and Technology

ED 582. Critical Literacy

COUNSELING AND HUMAN DEVELOPMENT COURSES

EDE 417. Crisis Counseling and Disaster Mental Health

ED 418. The Family and Social Dynamics

ED 419. Life Course Studies

EDE 422. Motivation in Human Development

ED 425. Minority Youth Development in Urban Contexts

ED 427. Elementary School Counseling

ED 429. Theories of Human Development

EDU 439. Interpersonal Systems in Counseling and Human Development

EDU 450. Introduction to School Counseling

EDU 453. Counseling and Facilitating in Small Groups

EDU 454. Career Counseling and Development

EDU 455. Policy and Practice in Developmental Differences

EDU 457. Counseling Theory and Practice I

EDU 459. Contemporary Issues in School Counseling

EDU 460. Counseling Theory and Practice II

EDU 465. Assessment and Appraisal

EDU 466. Problem Identification and Intervention in Counseling I

EDU 470. Multicultural Perspectives in Counseling
EDU 471. Counselor as Systems Consultant
EDU 472. Principles and Practices of Community Mental Health Counseling
EDU 473. Problem Identification and Intervention in Counseling II
EDU 474. Addictions Counseling and Prevention
EDU 479. Promoting Mental Health in Midlife and Old Age
EDU 494. Human Development in Old Age
EDU 549. Contemporary Learning Theories
EDU 552. Counselor Education
EDU 553. Counselor Supervision
EDU 554. Advanced Theory, Research, and Practice in Group Work
EDU 555. Advanced Counseling Theory, Research, and Practice
EDU 557. Selected Theories in Human Development
EDU 560. Research in Cognitive Development
EDU 563. Advocacy, Consulting, and Systems Change as Counseling and Human Development Practice
EDU 564. Contemporary Trends in Mental Health Appraisal, Intervention, and Research
EDU 565. Research in Life Course Studies
EDU 572. Development of Selves

EDUCATIONAL LEADERSHIP COURSES

EDU 403. Public School Choice
EDU 404. School Leadership in Diverse Settings
EDU 407. Curricular and Instructional Leadership
EDU 408. Law of Private Schools
EDU 409. Business Affairs in Private K–12 School Systems
EDU 411. Education Finance Issues in K–12 School Systems
ED 413. Student Affairs Administration: Academic Support Services
EDU 413. Contemporary Issues in Education Policy
EDU 416. Conflict Management in Schools and Universities
EDU 418. Leadership in Education
ED 420. Learning and Assessment in Higher Education
EDU 421. Human Resource Management
EDU 422. Educational Leadership: Implications for the 21st Century
EDU 423. Educational Management and Human Relations
EDU 424. The Principal and Christian Concepts of Virtue
ED 430. College Retention: Theory, Research, and Practice
ED 433. Student Affairs Administration: Admissions and Financial Aid
ED 434. Student Affairs Administration: Minority Student Affairs
ED 436. How Universities Work
EDE 435. Service Learning in Higher Education and the Public Good
ED 437. Diversity and Equity in Higher Education
ED 439. Policy Analysis in Education
ED 456. Leadership and Special Education
ED 462. Managing School Resources
ED 464. State and Federal Education Policy
ED 465. School Governance and Rights of Students and Teachers
ED 467. Student Affairs Administration: International Student Services
EDU 468. Data-Driven School Improvement
ED 469. Leadership and Organizational Dynamics
ED 470. Leading Effective Program Design
ED 473. Technology for Educational Leaders
ED 475. Leadership and Management in Higher Education
ED 476. Administration of Student Affairs in Higher Education
ED 479. Human Capital Management in Higher Education
ED 482. Technology and Higher Education

EDE 482. Principles and Components of Higher Education Advancement

EDE 483. Leadership & Management Competencies for Higher Education Advancement Administrators

ED 484. Student Affairs Administration: Residential Life

ED 485. College Students and Student Development Theory

EDE 485. Student Affairs Administration: Student Activities and Fraternity/Sorority Affairs

EDU 485. College Access and (In)Equity

EDE 487. The Role and Function of the American Community College in Higher Education

EDU 490. Higher Education Law

EDE 491. The Entrepreneurial University

EDU 492. Governance, Policy, and Administration of Higher Education

EDU 493. History of Higher Education

EDU 496. Fiscal Issues in Higher Education


EDU 515. Decision Making for Educational Leaders I: Analyzing Problems in Schools and Universities

EDU 516. Decision Making for Educational Leaders II: Making Decisions in Schools and Universities

ED 520. Program Evaluation

ED 521. Advanced Program Evaluation

EDU 576. Contemporary Issues in Higher Education

CONTINUATION OF ENROLLMENT

Students enrolled in any of the Warner School degree programs are required to maintain “continuous enrollment” for the entire duration of their program. Students who register for less than nine credit hours in a given academic year are required to register for one of the following options:

ED 895. Continuation of Master's Enrollment

ED 899. Master's Thesis
Inventory of Registered Programs

The New York State Education Department has authorized the University of Rochester to offer the graduate-level programs that appear in the following inventory. A listing of undergraduate programs may be found in the Official Bulletin: Undergraduate Studies. Undergraduate programs offered at the Eastman School of Music may be found in the Official Bulletin: Eastman School of Music.

School of Arts and Sciences

<table>
<thead>
<tr>
<th>Program Code</th>
<th>Hegis Code</th>
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### Margaret Warner Graduate School of Education and Human Development

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#### Educational Leadership

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Margaret Warner Graduate School of Education and Human Development
### Margaret Warner Graduate School of Education and Human Development

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**Teaching—professional certification for current teachers**

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**Non-degree—certificate programs**

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### William E. Simon Graduate School of Business Administration

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University Administration

Joel Seligman  
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University Senior Vice President for Health Sciences and CEO of University of Rochester Medical Center

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Co-Chair, Faculty Senate

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School of Nursing, 207–231
  Accreditation, 211
  Admission Requirements, 211–213
  Doctoral (PhD) Programs, 211–213
  Doctor of Nursing Practice (DNP) Program, 212–213
  Master of Science Programs, 211–214
  Leadership in Health Care Systems, 214
  Nurse Practitioner Master’s Programs, 213–214
  Post-Master’s Programs, 213–214
Security Services, University, 15–16
Simon Graduate School of Business Administration,
  William E., 233–238
  Admission Requirements, 237
  Executive MBA Programs, 236
  Joint Degree Programs, 236
  Master of Business Administration Program, 235
  Master of Science in Accountancy, 235–236
  Master of Science in Business Administration, 235
  Master of Science in Finance, 235–236
  PhD Program in Business Administration, 236–237
Standards of Conduct, see Conduct, Standards of
Statistics, see Biostatistics and Computational Biology
Student Support, 14–15
Student Life, Graduate, 12–16
Technical Entrepreneurship and Management (TEAM), 157–158
Toxicology, 204–206
Tuition, 17
Ultrasound, Rochester Center for Biomedical, 123
University Administration, 256
University Council on Graduate Studies, 256
University Counseling Center (UCC), 14
University Health Service (UHS), 13–14
Visual and Cultural Studies Program, 108–110
Visual Science, Center for, 108
W. Allen Wallis Institute of Political Economy, 113
Margaret Warner Graduate School of Education and Human Development, 239–249
  Admission Requirements, 240
  Certification Programs, 241–243
  Counseling and Human Development, 245
  Doctoral (PhD, EdD) Programs, 240–241
  Guaranteed Rochester Accelerated Degree in Education (GRADE), 245
  Master’s Programs, 241–243
  Non-Degree Programs, 243
  Scholarships, 244
  Undergraduates, Options for, 243–245
  Urban Teaching and Leadership Program, 244
Withdrawal, 26