This bulletin was prepared in the spring of 2006. 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 M.D. Program in the School of Medicine and Dentistry.

The University of Rochester values diversity and is committed to equal opportunity for all persons regardless of age, color, disability, ethnicity, marital status, national origin, race, religion, sex, sexual orientation, veteran status, or any other status protected by law. Further, the University complies with all applicable nondiscrimination laws in the administration of its policies, 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, PO. Box 270039, Rochester, New York 14627-0039. Phone (585) 275-9125.
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  Including tuition and fees, financial aid, and loan programs
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COURSE NUMBERING SYSTEM

1–99  Noncredit
100–199 Introductory undergraduate courses; no graduate credit
200–299 Junior and senior undergraduate courses; three hours of graduate credit unless otherwise specified
300–399 Undergraduate honors courses; three hours of graduate credit unless otherwise specified
400–489 Master's first-year-level courses; credit specified with course descriptions; open to undergraduates under certain conditions

Credit hours for courses that differ from the above table are given in the course descriptions.

NUMBER OF CREDIT HOURS to be specified at registration:
490–499 Master's-level reading and research courses
500–599 Advanced or specialized graduate courses and research; usually for doctoral-level students only
   895 Continuation of master's enrollment
   899 Master's dissertation
   985 Leave of absence
   990* Summer registration in residence
   995 Continuation of doctoral enrollment
   999 Doctoral dissertation

* 990 is not used by the College.
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.

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

<table>
<thead>
<tr>
<th>College/Program</th>
<th>Contact Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arts and Sciences</td>
<td>Director of Graduate Studies&lt;br&gt;Department of ______&lt;br&gt;University of Rochester&lt;br&gt;Rochester, New York 14627&lt;br&gt;www.rochester.edu/College</td>
</tr>
<tr>
<td>Engineering and Applied Sciences</td>
<td>Chair&lt;br&gt;Department of ______&lt;br&gt;University of Rochester&lt;br&gt;Rochester, New York 14627&lt;br&gt;www.rochester.edu/College</td>
</tr>
<tr>
<td>Eastman School of Music</td>
<td>Director of Admissions&lt;br&gt;Eastman School of Music&lt;br&gt;26 Gibbs Street&lt;br&gt;Rochester, New York 14604-2599&lt;br&gt;www.esm.rochester.edu</td>
</tr>
<tr>
<td>School of Medicine and Dentistry</td>
<td>Senior Associate Dean for Graduate Education&lt;br&gt;University of Rochester Medical Center&lt;br&gt;601 Elmwood Avenue, Box 316&lt;br&gt;Rochester, New York 14642-8316&lt;br&gt;E-mail: <a href="mailto:gradadm@urmc.rochester.edu">gradadm@urmc.rochester.edu</a></td>
</tr>
<tr>
<td>School of Nursing</td>
<td>Office of Student Affairs&lt;br&gt;University of Rochester&lt;br&gt;School of Nursing&lt;br&gt;601 Elmwood Avenue, Box SON&lt;br&gt;Rochester, New York 14642-8404&lt;br&gt;(585) 275-2375&lt;br&gt;www.urmc.rochester.edu/son</td>
</tr>
</tbody>
</table>
William E. Simon Graduate School of Business Administration
Detailed general brochure and brochures for M.B.A., Executive M.B.A., and Ph.D. programs

Margaret Warner Graduate School of Education and Human Development
Detailed general brochure

Admissions Office
William E. Simon Graduate School of Business Administration
304 Schlegel Hall
University of Rochester
P.O. Box 270107
Rochester, New York 14627-0107
E-mail: admissions@simon.rochester.edu
or phdoffice@simon.rochester.edu
or emba@simon.rochester.edu

Admissions Office
Margaret Warner Graduate School of Education and Human Development
Dewey Hall
University of Rochester
P.O. 270425
Rochester, New York 14627-0425
E-mail: warner@rochester.edu
www.rochester.edu/warner

The Official Bulletin: Undergraduate Studies is available from:
Director of Undergraduate Admissions
University of Rochester
P.O. Box 270251
Rochester, New York 14627-0251

Or check our Web site at www.rochester.edu/bulletin.
Graduate Studies Calendar, 2006–2008*

This calendar is prepared far in advance of publication. Please confirm deadlines with department and/or school offices.

FALL SEMESTER 2006

July 31    Completed applications for full-time graduate study for the fall semester should be submitted by this date.
August 31  Last day to submit two final corrected copies of the dissertation for October 2006 Ph.D. degree.
September 5 Classes begin.
September 19 Last day for registration and for payment of tuition and fees without late fee.
October 16 Fall term break. Classes resume October 17.
November 15 Completed applications for full-time graduate study for the spring semester should be submitted by this date.
November 22 Thanksgiving recess begins at noon. Classes resume November 27.
December 14 Reading period begins (optional by College offering course).
December 16–22 Final examinations.
December 22 Winter recess begins after last examination.

* Except for Ph.D. deadlines, 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).
SPRING SEMESTER 2007

January 16  Last day to submit two final corrected copies of the dissertation for March 2007 Ph.D. degree.
January 17  Classes begin.
January 31  Last day for registration and for payment of tuition and fees without late fee.
February 1  Last day to submit applications for admission in order to be considered for fellowships, assistantships, and scholarships for 2007–2008.
March 10   Spring recess begins. Classes resume March 19.
April 20   Last day to hold doctoral qualifying examinations in the spring semester.
April 27   Last day for final doctoral oral and master’s comprehensive oral examinations for May 2007 degree.
May 1      Last day to submit two final corrected copies of the dissertation for May 2007 Ph.D. degree.
May 3      Reading period begins (optional by College offering course).
May 7–14   Final examinations.
**FALL SEMESTER 2007**

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>July 31</td>
<td>Completed applications for full-time graduate study for the fall semester should be submitted by this date.</td>
</tr>
<tr>
<td>August 31</td>
<td>Last day to submit two final corrected copies of the dissertation for October 2007 Ph.D. degree.</td>
</tr>
<tr>
<td>September 4</td>
<td>Classes begin.</td>
</tr>
<tr>
<td>September 18</td>
<td>Last day for registration and for payment of tuition and fees without late fee.</td>
</tr>
<tr>
<td>October 8</td>
<td>Fall term break begins. Classes resume October 9.</td>
</tr>
<tr>
<td>November 15</td>
<td>Completed applications for full-time graduate study for the spring semester should be submitted by this date.</td>
</tr>
<tr>
<td>December 14</td>
<td>Reading period begins (optional by college offering course).</td>
</tr>
<tr>
<td>December 16–22</td>
<td>Final examinations.</td>
</tr>
<tr>
<td>December 22</td>
<td>Winter recess begins after last examination.</td>
</tr>
<tr>
<td>Date</td>
<td>Event Description</td>
</tr>
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<tr>
<td>January 15</td>
<td>Last day to submit two final corrected copies of the dissertation for March 2008 Ph.D. degree.</td>
</tr>
<tr>
<td>January 16</td>
<td>Classes begin.</td>
</tr>
<tr>
<td>January 21</td>
<td>Martin Luther King Day observed</td>
</tr>
<tr>
<td>January 30</td>
<td>Last day for registration and for payment of tuition and fees without late fee.</td>
</tr>
<tr>
<td>February 1</td>
<td>Last day to submit applications for admission in order to be considered for fellowships, assistantships, and scholarships for 2008–2009.</td>
</tr>
<tr>
<td>March 8</td>
<td>Spring recess begins. Classes resume March 17.</td>
</tr>
<tr>
<td>April 18</td>
<td>Last day to hold doctoral qualifying examinations in the spring semester.</td>
</tr>
<tr>
<td>April 25</td>
<td>Last day for final doctoral oral and master's comprehensive oral examinations for May 2008 degree.</td>
</tr>
<tr>
<td>April 29</td>
<td>Last day to submit two final corrected copies of the dissertation for May 2008 Ph.D. degree.</td>
</tr>
<tr>
<td>May 1</td>
<td>Reading period begins (optional by College offering course).</td>
</tr>
<tr>
<td>May 5–12</td>
<td>Final examinations.</td>
</tr>
</tbody>
</table>
KEY

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. Biomedical Engineering/ Optics Bldg.
20. Hylan Bldg.
21. Hutchison Hall
Hubbell 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. Quad Annex
30. Sigma Alpha Mu
31. Sigma Chi
32. Medieval House
33. Drama House
34. Burton Hall
35. Lovejoy Hall
36. Tiernan 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
    Squash and Racquetball Center
43. Fauver Stadium
44–48. Susan B. Anthony Halls
44. Gates Hall
45. Morgan Hall
46. Hollister Hall
47. Danforth Dining Center
48. Gannett Hall
49. Spurrier Hall
50. Sage Art Center
51–52. Founders Court
   51. Anderson Tower
   52. Wilder Tower
53. Facilities and Services Bldg.
54–59. Hill Court
   54. Fairchild House
   55. Gale House
   56. Slater House
   57. Munro House
   58. Kendrick House
   59. Chambers House
60–65. Mt. Hope Campus
   60. 575 Mt. Hope Ave.
   61. 590 Mt. Hope Ave.
   62. 630 Mt. Hope Ave.
      (Peter Barry House)
   63. 668 Mt. Hope Ave.
      (Ellwanger & Barry Bldg.)
   64. 692 Mt. Hope Ave.
      (Patrick Barry House)
   65. 685 Mt. Hope Ave.
      Fairbank Alumni House
66. Towne House
67. Data Center Services (DCS)
68. Mt. Hope Professional Bldg.
69. Mail Services Bldg.
70. Goler House
71. Eastman Dental Center
72. Parking Garage
73. Ambulatory Care Facility
74. Hospital Lobby
75. Strong Memorial Hospital
76. Frank and Caroline Gannett Emergency Center
77. Supplies & Accounts Bldg.
78. James P. Wilmot Cancer Center
79. University Health Service
80. School of Medicine and Dentistry
81. Medical Center Annex
82. Central Utilities Plant
83. Arthur Kornberg Medical Research Building
84. Medical Research Building Extension
85. Helen Wool Hall
86. KinderCare Learning Center
87. University Park
88. Graduate Maisonettes
89. de Kiewiet Tower
90. Valentine Tower
91. Administrative Annex
92. Center for Optoelectronics and Imaging
93. Robert L. Sproull Center for Ultra High Intensity Laser Research
94. Laboratory for Laser Energetics
95–96. River Road Complex
95. River Road Residence
96. River Road Laboratory
97. Whipple Park Apartments
University of Rochester

GRADUATE EDUCATION

The University of Rochester is an independent university which offers over 40 doctoral programs and some 60 master’s programs in the following schools and colleges:

- The College
  - Arts and Sciences
  - 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

In 2006, the University reached a milestone in its history of graduate education, awarding its 8,000th Ph.D. degree. The first Ph.D. degree had been 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.

The University has some 1,223 tenure-tracked faculty members and roughly 7,240 full-time students and 1,185 matriculated part-time students. Of the full-time students, 4,420 are undergraduates and 2,820 are graduate students.

These 2,820 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 Divinity School-Bexley Hall-Crozer Theological Seminary-St. Bernard's Seminary 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 e-mail at uapts@reslife.rochester.edu or check the Web site at www.reslife.rochester.edu.

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 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 e-mail ochousing@reslife.rochester.edu or check the Web site at www.reslife.rochester.edu/non/topics.php.

GRADUATE STUDENT ORGANIZATIONS

Graduate student organizations are as follows: the College (Arts, Sciences, and 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 School Student Association.

HEALTH 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 Joint Commission on Accreditation of Healthcare Organizations (JCAHO).

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
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.

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 considered 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 medical offices. Students are asked to call 275-2662 to schedule an appointment at any one of the three UHS offices. The UHS Medical Center Office is open weekdays throughout the year. The UHS River Campus Office is open seven days a week during the academic year except school vacations. The UHS office at the Eastman School of Music is open weekdays during the academic year except school vacations.

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 (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 or come to 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 information, call 273-5775.

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 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 the student not being allowed to attend 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, call (585) 275-0697 or write to hhf@uhs.rochester.edu.

UHS Web Site (www.rochester.edu/uh)

The UHS Web site provides detailed information about the services provided by UHS, the locations and hours, the clinical staff, the mandatory health fee, and health insurance. In addition, the site provides brochures written by UHS staff on a number of health topics and links to other online health care sites.
UNIVERSITY COUNSELING CENTER (UCC)

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 addition 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.

Confidentiality

All contacts with a University Counseling Center therapist are confidential. The fact that a student is using UCC will not be disclosed to any University official or faculty member, or to family, friends, or roommates without the permission of the student. UCC will not release any clinical information about a student’s visit, even with a student’s 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 separate from both University Health Service medical charts and Strong Memorial Hospital medical records.

Locations

UCC has offices in Dewey Hall on the River Campus, in the University Towne House at the corner of Mt. Hope and Elmwood Avenues, and at the Eastman School of Music. The offices in Dewey Hall and in the University Towne House are open weekdays throughout the year. The office at the Eastman School of Music is open during the academic year. Students are asked to call 275-2361 or 275-3113 to schedule an appointment.

Urgent Situations and After-Hours Care

The University Counseling Center offers on-call emergency service 24 hours a day throughout the year for students who are distressed themselves or who are concerned about someone else. The professional-on-call can be reached by calling 275-2361 or 275-3113.

The UCC Web Site (www.rochester.edu/ucc)

The UCC Web site provides information about the University psychological services and links the reader to other online health care sites. Mental health questions can be addressed to the UCC online resource, “Dear Dr. Analyze.” Designed as a forum for discourse on mental health concerns, this site is to be used strictly as an educational tool and in no way attempts to replace formal therapy.
STUDENT SUPPORT

Learning Assistance Services (Lattimore 107) provides individual and group programs for students who want to improve their academic performance. For more information, please call 275-9049 or check our Web site at www.rochester.edu/College/las.

The booklet Classroom Accommodations, A Guide for Students with Disabilities, is available through the Office of Learning Assistance Services at 275-9049 or through the Office of University Disability Resources at 275-5550. Staff from both of these offices work closely with students with disabilities to verify documentation of the existence of a disability, implement 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 of problems 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 are responsible for handling concerns regarding sexual harassment; ethnic and racial issues; 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 for approximately 1,200 international students and 500 scholars from 90 countries. The staff administers the F-1 student and J-1 student and scholar visa programs, issues visa documents, and provides advice on immigration regulations affecting internationals. The ISO is responsible for reporting information on international students and scholars to the Student and Exchange Visitor Information System (SEVIS), the U.S. government’s newly implemented database. The ISO is also the University’s official liaison with the Department of Homeland Security, the Department of State, and foreign and American consulates and embassies. It 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 adjust to the United States, the University, and the community of Rochester. Services and programs include an annual orientation program; a biweekly newsletter; travel, employment, and tax workshops; a comprehensive Web site (www.iso.rochester.edu); and individual counseling to assist internationals in coping effectively with personal and cultural adjustment issues.

The ISO is located in 209 Morey Hall and can be contacted by phone at (585) 275-2866; by e-mail at questions@iso.rochester.edu; or by fax at (585) 244-4503.
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 Industrial Hygiene 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 life on the River Campus. The chapel staff offers graduate students opportunities for worship and meditation, social service and 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 Web site: www.security.rochester.edu.

Information on sexual harassment policies and procedures is published in the brochure Prevention of Harassment and Discrimination, which is available by calling the Intercessor's Office at (585) 275-9125.

How to Contact Security

The University maintains an extensive network of over 300 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 100 direct-dial Blue Light Emergency Phones.
In an EMERGENCY, dial x13 from any University phone, including over 50 “service” phones located at building entrances. Pick up a Blue Light Emergency Phone located on or near walkways and parking lots, and an officer will be sent to your location right away. Local police, fire, or ambulance agencies will be notified as needed.

For nonemergencies, dial x5-3333 from any University phone. 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 x5-3333.

For crime prevention services, call x5-2220. For investigative services, call x5-3436. For victim’s assistance, call x5-3108.

Where to Find Security

To emphasize community-based services, we operate two satellite offices in addition to our main administrative office. These resources are devoted to neighborhood-affiliated efforts, whether defined by program or campus. Senior managers for the River Campus and Eastman School of Music, Medical Center, and Emergency Communications and Technical Services are available to discuss your needs, questions, and concerns.

River Campus and Eastman School of Music—Community Learning Center, garden level. Office hours are 8:30 a.m.–5:00 p.m. weekdays. Telephone: (585) 273-5200. Fax: (585) 273-1128. While this office is located on the River Campus, staff are available to meet with community members at Eastman. We have limited office space in the Main Hall of Eastman School and the main lobby of the Student Living Center. Please call x3-5200 for further information.

Medical Center—Room G-6009 (near the bookstore and bank). Office hours are 8:30 a.m.–5:00 p.m. weekdays. Telephone: (585) 275-2221. Fax: (585) 271-4513.

Administrative offices—University Towne House, Suite 102, 1325 Mt. Hope Ave. Office hours are 8:30 a.m.–4:30 p.m. weekdays. Telephone: (585) 275-3340 or (585) 275-3437. Fax: (585) 275-0344.

Security Telephone Numbers to Remember

- Security/Fire/Ambulance EMERGENCY: x13
- Nonemergencies: x5-3333
- River Campus and Eastman Office: x3-5200
- Medical Center Office: x5-2221
- Administrative and Patrol Operations Staff: x5-3340
- General Information (e-mail): 4_info@security.rochester.edu
- Special Events: x5-1087
- Lost/Found Property: x5-2552
- Victim Assistance Coordinator: x5-3108

For more information, please visit our Web site 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 2006–2007 academic year are shown below and are subject to revision. Payment dates for tuition and other fees are shown in the calendar on pages 6–9.

Rates for 2007–2008 may be different from the rates shown below; if so, new information about tuition and fees will be issued.

TUITION

Full-Time Graduate Tuition

The College (arts, sciences, and engineering) and the School of Medicine and Dentistry M.S. and Ph.D. programs ............... $1,020/credit hour
Margaret Warner Graduate School of Education and Human Development ......................... $948.00/credit hour
School of Nursing ........................................... $950.00/credit hour
William E. Simon Graduate School of Business Administration .................................... $1,192/credit hour
School of Medicine and Dentistry (M.D. program) ...... $35,800 (annual)
Eastman School of Music ................................. $945/credit hour*
899: master's dissertation, per semester ....................... $816
999: doctoral dissertation, per semester ....................... $816
Each of the above, Eastman School of Music, per semester ...... $816
Each of the above, Simon School, per quarter ................ $500

The tuition for full-time graduate students covers courses receiving graduate credit and includes fees for laboratory courses. It does not include courses unrelated to the student's academic program for which the student wishes academic but not graduate credit.

Part-Time Graduate Tuition

Nonmatriculated students in courses in arts and sciences† .................................. $570 per credit hour
School of Engineering and Applied Sciences ...... $1,020 per credit hour
Eastman School of Music
excluding applied music courses ....................... $945 per credit hour
Applied music courses ..................................... varies
School of Medicine and Dentistry .................... $1,020 per credit hour
School of Nursing ........................................ $950 per credit hour

* 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.
William E. Simon Graduate School of Business Administration ............... $1,192 per credit hour
Margaret Warner Graduate School of Education and Human Development ............... $948 per credit hour

FEES

The fee for auditing courses is $100 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 $310 per course. The Simon School’s auditing fee is $1,788 per three-hour course.

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

Other fees are
Mandatory Health Service Fee charged to all full-time students ........ $552
Late registration fee* .................................................. $150
Rematriculation fee (can vary by school) ................................. $50
Microfilming fee for the Ph.D., D.M.A., or Ed.D. degree before registering the dissertation ............................................... $50
Health History Form late fee .................................................. $30
895: continuation of master’s enrollment, per semester ............... $816
995: continuation of doctoral enrollment, per semester ............... $816
For William E. Simon Graduate School of Business Administration, 995, per quarter ....................... $500
For Eastman School of Music, 895 and 995, per semester† ......................... $816
985: leave of absence, per semester ........................................... $50
For the Eastman School of Music and School of Nursing, 985, per semester ........................................... $60

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

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,

* 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.
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 of Charges

In the event that a student must withdraw from all coursework during a period of enrollment, the following schedule for refund of tuition and mandatory fees is to be applied:

<table>
<thead>
<tr>
<th>Academic Year 2006/2007</th>
<th>Fall 2006</th>
<th>Refund</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effective Date</td>
<td>09/05–09/10/06</td>
<td>100%</td>
</tr>
<tr>
<td>Effective Date</td>
<td>09/11–09/17/06</td>
<td>90%</td>
</tr>
<tr>
<td>Effective Date</td>
<td>09/18–10/08/06</td>
<td>50%</td>
</tr>
<tr>
<td>Effective Date</td>
<td>10/09–10/29/06</td>
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<tr>
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<td>10/29/06</td>
<td>0%</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Spring 2007</th>
<th>Refund</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effective Date</td>
<td>01/17–01/21/07</td>
</tr>
<tr>
<td>Effective Date</td>
<td>01/22–01/28/07</td>
</tr>
<tr>
<td>Effective Date</td>
<td>01/29–02/18/07</td>
</tr>
<tr>
<td>Effective Date</td>
<td>02/19–03/11/07</td>
</tr>
<tr>
<td>No Refund After</td>
<td>03/11/07</td>
</tr>
</tbody>
</table>

Separate schedules for the Simon School, Warner School, School of Nursing, and the Eastman School can be obtained from the Registrar’s Office at each school.

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 New York State.

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 that 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.”

Government Programs

The New York State Tuition Assistance Program (TAP) is a need-based, tuition-specific grant offered to qualified students who are legal New York State (NYS) residents and attending a NYS school. In addition to the FAFSA, a separate TAP application is required by the state and will be made available online once the FAFSA has been filed. Award amounts are based on income, and current graduate award amounts range from $75–$550 per academic year. Students with full (100 percent) tuition waivers who are eligible for TAP will see no net increase in their total financial aid, as this departmental award money must be replaced dollar-for-dollar by the amount of their TAP award. Students must be registered full-time (12 CH/sem. or equivalent) and must incur a tuition liability to be eligible for TAP (students registered solely as dissertation are not eligible, as they are not charged tuition). The deadline to apply for TAP is May 1st of the academic year for which the student is applying. Additional information can be found through NYS HESC at www.hesc.com, (888) 697-4372, or through the University of Rochester Financial Aid Office at www.enrollment.rochester.edu/financialaid or (585) 275-3226.

FINANCIAL ASSISTANCE

Federal Direct Loan: Graduate students may borrow up to a maximum of $18,500 per year. The amount may be in the form of a subsidized or unsubsidized Federal Direct Loan. The federal government will pay the interest on the subsidized Federal Direct Loan while the recipient is enrolled at least half-time. Unsubsidized Federal Direct Loans will accrue interest during in-school and grace periods. The 10-year repayment period begins six months after recipients cease to be enrolled at least half-time.

Students must complete their disbursement requirements, including signing any promissory notes and completing entrance counseling, and be registered before a loan can be disbursed to their account.

Federal Nursing Loan: The yearly amount awarded varies according to financial need; however, the total borrowed cannot exceed $13,000. Repayment begins nine months after termination of studies at 5 percent interest.
Alternative, private loan programs through various lenders such as Nellie Mae and Citibank are available to credit-worthy applicants. These loans have variable interest rates and the option to defer payment while in school. Applications and information are available through the Financial Aid Office, or online at www.enrollment.rochester.edu/financialaid.

Application Procedures

Graduate students who wish to apply for loans should do so soon after accepting an offer of admission to ensure their financial assistance is processed in a timely manner. Financial need must be verified through a standardized and approved system for the analysis of federal eligibility. The Free Application for Federal Student Aid (FAFSA) is required. Students will also be asked to submit supporting documentation, including an institutional form and federal tax returns.

Further information is available from:

Eastman School of Music: Office of the Director of Financial Aid, Room 103, Eastman School of Music, 26 Gibbs Street, Rochester, New York 14604-2599.

School of Medicine and Dentistry: Office of Financial Aid, School of Medicine and Dentistry, 601 Elmwood Avenue, Box 601, Rochester, New York 14642-8601.

All other schools and colleges of the University: Financial Aid Office, 3rd Floor Meliora Hall, University of Rochester, P.O. Box 270261, Rochester, New York 14627-0261, or online at www.enrollment.rochester.edu/financialaid.
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, 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:

THE COLLEGE (ARTS AND SCIENCES)
Biology
Brain and Cognitive Sciences
Chemistry
Computer Science
Economics
English
Geological Sciences
History
Linguistics*
Mathematics
Philosophy
Physics
Physics and Astronomy
Political Science
Psychology (Clinical, Developmental, and Social-Personality)
Visual and Cultural Studies

THE COLLEGE (SCHOOL OF ENGINEERING AND APPLIED SCIENCES)
Biomedical Engineering
Chemical Engineering
Electrical Engineering
Materials Science
Mechanical Engineering
Optics

EASTMAN SCHOOL OF MUSIC
Music Composition
Music Education
Music Theory
Musicology

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

SCHOOL OF NURSING
Nursing

WILLIAM E. SIMON GRADUATE SCHOOL OF BUSINESS ADMINISTRATION
Business Administration

MARGARET WARNER GRADUATE SCHOOL OF EDUCATION AND HUMAN DEVELOPMENT
Education

* New enrollments suspended.
THE DEGREES DOCTOR OF MUSICAL ARTS, DOCTOR OF MEDICINE, 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; and for the Doctor of Education at the Margaret Warner Graduate School of Education and Human Development, www.rochester.edu/Warner.

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.”

THE COLLEGE (ARTS AND SCIENCES)
Biology (M.S.) A,B
Brain and Cognitive Sciences (M.A.) A,B
Chemistry (M.S.) A,B
Comparative Literature (M.A.) A,B
Computer Science (M.S.) B
Economics (M.A.) B
English (M.A.) B
French (M.A.) A,B
Geological Sciences (M.S.) A,B
German (M.A.) A,B
History (M.A.) A
Interdepartmental Studies (M.A., M.S.) A,B
Linguistics (M.A.) A,B
Mathematical Methods (M.S.) B
Mathematics (M.A.) B
Mathematics-Applied (M.S.) A,B
Mathematics-Statistics (M.A.) B
Philosophy (M.A.) A,B
Physics (M.A.) B, (M.S.) A
Political Science (M.A.) A,B
Psychology (M.A.) A,B
Spanish (M.A.) A, B
Visual and Cultural Studies (M.A.) B

THE COLLEGE (SCHOOL OF ENGINEERING AND APPLIED SCIENCES)
Biomedical Engineering (M.S.) A,B
Chemical Engineering (M.S.) A,B
Electrical Engineering (M.S.) A,B
Materials Science (M.S.) A,B
Mechanical Engineering (M.S.) A,B
Optics (M.S.) A,B

EASTMAN SCHOOL OF MUSIC
Ethnomusicology (M.A.)
Music Composition (M.A.) A
Music Education (M.A.) A
Music Theory (M.A.) B
Music Theory Pedagogy (M.A.) B
Musicology (M.A.) B

SCHOOL OF MEDICINE AND DENTISTRY
Biochemistry (M.S.) A,B
Biophysics (M.S.) A,B
Dental Science (M.S.) A
Genetics (M.S.) A,B
Marriage and Family Therapy (M.S.) A,B
Medical Statistics (M.S.) B
Microbiology-Medical (M.S.) A,B
Neurobiology and Anatomy (M.S.) A,B
Neuroscience (M.S.) A,B
Pathology (M.S.) A
Pharmacology (M.S.) A,B
Physiology (M.S.) A,B
Statistics (M.A.) B
Toxicology (M.S.) A,B
SCHOOL OF NURSING  
(offered as traditional and accelerated programs)
- Acute Care Nurse Practitioner (M.S.) A,B
- Adult Nurse Practitioner (M.S.) A,B
- Care of Children and Families—Pediatric Nurse Practitioner/Neonatal Nurse Practitioner (M.S.) A,B*
- Care of Children and Families—Pediatric Nurse Practitioner (M.S.) A,B
- Family Nurse Practitioner (M.S.) A,B
- Gerontological Nurse Practitioner (M.S.) A,B
- Leadership in Health Care Systems (M.S.) B
- Pediatric Nurse Practitioner/Psychiatric/Mental Health Nurse Practitioner (M.S.) A,B
- Psychiatric/Mental Health Nurse Practitioner (M.S.) A,B

WILLIAM E. SIMON GRADUATE SCHOOL OF BUSINESS ADMINISTRATION
- Accountancy (M.S.)
- Business Administration (M.S.) A

MARGARET WARNER GRADUATE SCHOOL OF EDUCATION AND HUMAN DEVELOPMENT
- Counseling (M.S.)
- Higher Education (M.S.)
- Human Development (M.S.)
- School Administration (M.S.)
- Teaching and Curriculum (M.S.)

See www.rochester.edu/warner for specific degree offerings.

* No accelerated program.

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 279.)
2. Master of Music through the Eastman School of Music. (See page 194.)
3. Master of Arts in Teaching through the Margaret Warner Graduate School of Education and Human Development. (See page 289.)
4. Master of Public Health through the School of Medicine and Dentistry. (See page 218.)
Regulations and University Policies
Concerning Graduate Study

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. An applicant’s qualifications are examined by the relevant department/program of major interest and by the associate dean for graduate studies in the appropriate school or college to determine whether previous training and ability promise success in work for advanced degrees. Admission to a graduate degree program at the University of Rochester is for that program alone. Admission to any other program requires a completely new admissions application.

Additional admission requirements are set by certain schools and colleges of the University. These are stated separately in the general announcements of each school or college in this bulletin.

Individual departments, with the approval of their associate deans for graduate studies, may limit the number of graduate students to be admitted, determine the credit hours of prerequisite study, stipulate language requirements, or set other special admission requirements.

Special students have satisfactory undergraduate records except that they lack prerequisite courses for the intended area of graduate study. Such prerequisites must be completed within a year, and a student will not be continued as a special student beyond this time. Admission as a special student does not guarantee subsequent admission and matriculation with full graduate-student status.

Probationary admission may be granted to a student on approval by the associate dean for graduate studies in the appropriate school and the department of major interest when the applicant’s credentials indicate only marginal preparation for graduate work. Such a student can be admitted to full standing upon completing, at the discretion of the department, from 12 to 24 semester hours of graduate credit with all grades of at least B. If the student receives any grade lower than B, enrollment in graduate studies is subject to termination. (For School of Nursing, see Student Handbook relating to probation policies.)

Occasionally a student without a bachelor’s degree is admitted because of demonstrated high academic competence; however, all students taking post-baccalaureate work are considered graduate students. In certain cases, applicants who do not meet all the requirements for admission may be admitted conditionally. Their standing is reviewed after the first term of study to decide on their continuation in graduate work.

A person wishing to take a graduate course or courses not leading to a degree may register as a nonmatriculated student.* Subsequent evaluation of such work for inclusion in a graduate program is subject to the limitations on transfer

* Approval of the associate dean is required for the Eastman School of Music; approval of the director of doctoral programs for doctoral courses for the School of Nursing. In the Simon School, approval of the associate dean is required for courses other than the basic four core courses.
credit stated in the sections “Regulations for the Degree of Doctor of Philosophy: Transfer Credit,” and in “Master’s Degrees: General Requirements: Transfer Credit.”

All full-time students, upon formal acceptance, are required to submit a health certificate filled out by a primary care provider on University forms.

REGISTRATION

Colleges/schools in the University may have slightly different registration procedures. Refer to the Preface in the University of Rochester Course Schedule for particular college deadlines or check the relevant college/school Web site.

Registration must be completed within the first full 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.

A full-time graduate student is defined as a student who registers for at least 12 hours of credit for the semester, or a graduate assistant or other student doing work essentially 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 this policy.

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), and notifies the graduate registrar on the proper form. 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 for 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 for 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 of 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.

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 for graduate studies. There is a fee for this. With the approval of the associate dean of graduate studies, the college/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.*
Matriculation and Categories of Registration†

Matriculation

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 every semester (every quarter in the Simon School) and paying the required fee until all requirements for the degree are completed. Auditing a course does not fulfill this requirement. Categories of registration are listed below.

Summary of Special Registrations

- 890: master's summer in residence (full time)
- 895: continuation of master's enrollment (x-time)
- 899: master's dissertation (full time)
- 985: leave of absence (x-time)
- 990: doctoral summer in residence (full time)
- 995: continuation of doctoral enrollment (x-time)
- 999: doctoral dissertation (full time)

Rematriculation

Students who have previously matriculated here and 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;
(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.

Study in Residence

A student is defined as being in residence at the University of Rochester if he or she is registered 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 residence at this University is required for all advanced degrees. (See departmental residence requirements stated in this bulletin.)

* Students in the College have the option of changing a registered audit to credit up to 10 working days (two weeks) prior to the last day of classes in that semester. A fully endorsed drop/add form (signatures of instructor(s) and the faculty advisor are required) stamped in the Office of the Bursar must be submitted to the College Graduate Studies Office by that date.

† Change of time status (i.e., full time to part time, or full time to x-time—see the footnote for the section “Leave of Absence” for the definition of x-time) requires approval from the associate dean, except for the Warner School and the School of Nursing.
Students who have been classified as full time during the preceding academic year are classified as full-time graduate students during the summer. Students enrolled for the summer, even though the number of credit hours for which they are registered may be less than that otherwise defined as full time, are also classified as full-time students. 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

In certain circumstances it may be desirable for a matriculated graduate student to engage in full-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 at the University of Rochester. All such requests must be made in writing and must be approved in advance by the associate dean for graduate studies.

Leave of Absence (Non-Medical)*

Upon the recommendation of the department, the associate dean for 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.

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 go on a medical leave of absence must petition the student’s school or college. The school or college 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 or college 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. Contemporaneous evidence of both is required.

The school or college will make the decision concerning the 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.

* Leave of absence is an x-time category of registration which has implications on health insurance eligibility, possible loan deferments, and visa status. X-time is defined as neither a full-time or 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.
Except in unusual situations, as determined by the school or college 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 or college. The school or college 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 or college regarding the appropriateness of allowing the student to return from medical leave of absence. The recommendation will be based on evidence that the condition that required the leave is under sufficient control to allow the student to make a successful return.

The school or college 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 or college 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.

Dissertation Enrollment for Students in Residence

A candidate for the doctoral degree who has completed at least 90 semester hours of graduate credit beyond the bachelor's degree (or 60 hours beyond an accepted master's degree, or more if required in the doctoral program), who has completed all requirements for the degree except the dissertation, and who is continuing in residence will register each semester with the approval of the advisor or research director for “999: doctoral dissertation” and will be regarded as a full-time student. Such a student will not be subject to the usual tuition charges, but will pay the designated fee for this registration as well as all required health fees.

Upon written request and with the prior approval of the associate dean for graduate studies, “999” registration may also be elected by eligible candidates not in residence who are entitled to full-time student status.

A candidate for the master's degree who has completed at least 30 semester hours of graduate credit, who has completed all requirements for the degree except writing the dissertation, and who is continuing in residence will register, with the approval of the advisor, for “899: master's dissertation” for the completion of the master's dissertation. Such a student will not be charged tuition but will pay the designated fee for this registration as well as all required health fees.

Dissertation Enrollment for Students Not in Residence

Upon written request and with prior approval of the appropriate associate dean for graduate studies, a student may be granted permission to complete the doctoral dissertation while not in residence as a full-time student, if during such a period the faculty advisor or research director is able to maintain close supervision of the work. A student in this status (x-time) must maintain enrollment as a doctoral degree candidate by registering each semester for “995: continuation
of doctoral enrollment” and paying the designated fee for this registration. A student completing a master’s degree under these conditions must register for “895: continuation of master’s enrollment.” All students must maintain continuous enrollment. If enrollment is allowed to lapse, students must pay the appropriate fee for unregistered semesters in order to register the dissertation.

Registration of Dissertation (Ph.D. and Master’s)

Ph.D. dissertations are submitted for registration in the office of the appropriate associate dean for graduate studies. After approval by the associate dean, the Ph.D. dissertation is considered registered when it is accepted in the Office of the University Dean of Graduate Studies. Master’s dissertations are registered in the office of the appropriate associate dean for graduate studies. Students must pay the appropriate fee for unregistered semesters (or quarters for the Simon School) in order to register the dissertation. Instructions for the preparation of dissertations are available in the Office of the University Dean of Graduate Studies, the Office of the Associate Dean for Graduate Studies, in departmental offices, or on the University’s Web site at www.rochester.edu/theses.

Refund of the Current Semester or Quarter Fee

When the final two corrected copies (one for the School of Medicine and Dentistry and the School of Nursing) of the dissertation are turned in, the student is eligible for a refund of the current fee for continuing enrollment according to the following schedule: 75 percent during the first calendar month of the semester or first three weeks of the quarter for the Simon School, 50 percent during the second calendar month of the semester or second three weeks of the quarter, or 25 percent 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 Ph.D. students, and in the Office of the Associate Dean for Graduate Studies for master’s students.

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 for graduate studies in consultation with the student and the program director. Individual colleges 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 the College should refer to the “Policies Governing Use of the Grade of Incomplete in Graduate Courses” in the College 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.

Doctoral students who have registered for a total of at least 90 hours or more beyond the bachelor’s degree, but whose accepted and completed hours are fewer than 90, may register for “999: doctoral dissertation” only with written approval of the appropriate associate dean for graduate studies. (See the School of Nursing Ph.D. handbook for the policy regarding the use of “999.”)

Any student whose enrollment is continued will be considered to be in good academic standing.

PROGRAMS OF STUDY†

A faculty advisor will generally be named for each student by the end of the first year of study. The advisor assists the student in developing a complete program of study for the anticipated degree. Each program and all subsequent changes must be approved by the student’s advisor and the associate dean for graduate studies. Students who take courses without the approval of the advisor and the associate dean, or without registering for them, may not receive credit toward their degree requirements.

Ph.D. programs, approved by the department chair, program director, or their representative, should be filed with the associate dean for graduate studies no later than two years after initial registration as a matriculated student.

Master’s degree programs must be filed no later than the date specified by the college.

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 be recommended for the degree at the next meeting of the Board of Trustees, but will receive the diploma at the following Commencement.

* In the School of Nursing a grade of C automatically places a master’s student on probation. Policies regarding student progression rest with the standing faculty committee and the Student Affairs Committee, not the faculty advisor.

† Credit hours used for two graduate degrees cannot be used for another graduate degree at the University.
TRANSCRIPTS

Transcripts of graduate work will be issued only at the written request of the student. There is no transcript fee for graduate students in the College. A maximum of 30 transcripts may be ordered. Requests for more than 30 transcripts will be charged $2.00 per copy. 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.

WITHDRAWAL

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 for graduate studies.

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 August 3 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.

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.

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. These resources are intended to facilitate activities that are important to the University.

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 fed-
eral and state computer crimes statutes. Violations include, but are not limited to, commercial activities not approved by the University; using information technology resources to harass or to create, store, or transmit libelous or obscene materials; copyright and licensing infractions; and infringing on rights of personal privacy. (see 8.20.07 Addendum on File Sharing)

DISCIPLINARY PROCEDURES AND GUIDELINES

When students violate the University’s rules and regulations, they may be subject to disciplinary action. Any student accused of misconduct will be treated in accordance with standards of fundamental fairness as explained on pages 45–47.

Detailed information on the Student Discipline Guidelines is outlined below as follows:

The Nature and Objectives of the University
Basic Rights and Expectations
The University and the Public Law
Division of Jurisdiction and Responsibility
Standards of Conduct
Judicial Process
Fundamental Fairness
Sanctions
Appeals
Disciplinary Records
Academic Misconduct
Harassment and Discrimination

THE NATURE AND OBJECTIVES OF THE UNIVERSITY

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.

BASIC RIGHTS AND EXPECTATIONS

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.
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 unacceptable behavior. 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. Universities, in contrast to the state, do not have fully trained police or investigative units, do not have legal counsel in preparing or presenting cases, and have 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.

THE UNIVERSITY AND THE PUBLIC LAW

A. 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.

B. 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.

C. Students may be subject to University discipline 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.

DIVISION OF JURISDICTION AND RESPONSIBILITY

A. Authority to discipline students (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 to the judicial officer in the Office of the Dean of Students of the College (“the judicial officer”) for all nonacademic discipline involving graduate students with a further delegation to disciplinary hearing teams. These disciplinary hearing teams determine, on the basis of the standards of the University community, whether a given alleged act can be said to have occurred by the preponderance of the evidence and if so, the response which is most likely to uphold community standards and educate the individual who committed the act. As the University official responsible for discipline, the judicial officer receives the recommendation of these groups on behalf of the University, accepts or modifies the recommendation, and formally implements University disciplinary action.
B. Jurisdiction over cases of academic misconduct involving graduate students has been delegated to individual department hearing panels who, in consultation with the associate dean for graduate studies, make findings and submit recommendations to the University dean of graduate studies.

C. 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.

D. 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 retains the right to summarily 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. Summary suspension, removal from housing, or other interim restrictions may be imposed before, during, or after a hearing and any appeal process.

E. 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 agencies shall report serious violations of such rules and regulations to the judicial officer.

STANDARDS OF CONDUCT

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 which 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.

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

1. Fraud, misrepresentation, forgery, falsifying documents, records, or identification cards, fabricating research data, plagiarism, and other scientific and academic misconduct. (See Academic Misconduct below.)
2. Unlawful use, manufacture, sale, distribution, or possession of alcohol, drugs, narcotics, or controlled dangerous substances.
3. Unlawful or improper possession, distribution, or use of firearms, knives, or other dangerous weapons.
4. Disorderly conduct, including fighting, threats, harassment, or other conduct which threatens the health or safety of another.
5. Obstruction, disruption, or noncooperation with a disciplinary hearing process, including perjury, and the failure to comply with an imposed sanction.
6. Failure to comply with any reasonable request of a University official acting within the scope of his or her duties.
7. Theft and/or damage to the property of the University or others.
8. Unauthorized use 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 normal activities of others on campus.
9. Hazing, which may include actions taken or situations created to produce mental or physical harm, discomfort, embarrassment, harassment, or ridicule.
10. Sexual harassment, racial harassment, or any other form of illegal discrimination. (See Harassment and Discrimination policies outlined below.)
11. Sexual misconduct, including any form of unwanted sexual contact. “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.
12. Any violation of the University’s policies, rules, or regulations.

JUDICIAL PROCESS

All complaints against graduate students should be forwarded to the appropriate associate dean for graduate studies within that student’s school or college 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 49–52. 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 screens cases and is obligated to make judgments on the disposition of disciplinary complaints of a nonacademic nature. The judicial officer has several basic options with any given complaint:

a. Dismiss the complaint as groundless or trivial.

b. Decide that the complaint should be handled as an administrative matter.

c. Direct the complaint to mediation or some other informal means of resolution.

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.
NONACADEMIC MISCONDUCT

Judicial officer receives a written report from a member of the University community

Judicial officer meets with persons involved

Case dismissed

Judicial officer charges student with policy violation(s)

Student accepts responsibility for policy violation(s)

Judicial officer sanctions student

Student requests disciplinary hearing

Informal or administrative resolution

Administrative hearing

Hearing

Recommendation to judicial officer

Decision of judicial officer to student and victim, if any

Student/Victim appeals decision to appropriate dean/director

Decision accepted

Decision modified

Decision upheld
Normally within 14 days after a student is charged the hearing team will be convened. The accused student will receive notice of the hearing at least 7 days before the hearing. If these time lines cannot be met, the judicial officer will advise the accused (and any other participants who need to know) of the reason and an alternative time line.

The judicial officer will hold an informational session with each of the persons involved in the complaint or named in the report to discuss the charges put forth and the hearing process. The judicial officer may take any reasonable steps to insure an orderly hearing process, including asking other members of the University community, not explicitly named or involved in the official report or complaint, to take part in the judicial process as the judicial officer deems appropriate for the proper and true adjudication of the matter. The judicial officer has full discretion to make appropriate changes, additions, or clarifications to the disciplinary procedures depending on the circumstances.

In cases where the student will have a judicial hearing, the judicial officer will give him or her a copy of the Regulations and University Policies Concerning Graduate Studies, which explains the University’s judicial process and the student’s rights.* The judicial officer will also give the student one day to choose an administrative hearing.

The administrative hearing team normally consists of four (at least three, but no more than six) faculty and/or staff and/or graduate students of the University. The administrative hearing team is selected by the judicial officer (in consultation with the appropriate associate dean for accused graduate students) from a group of approximately 20 faculty, staff, and graduate students from throughout the University who serve as a standing committee to hear such complaints. Panelists will be selected to provide balance and to ensure that no panelist is a member of either party’s academic department or field of interest. Cases of allegations involving sexual assault, sexual harassment, racial harassment, and other illegal discrimination are reviewed by administrative hearing team members who have been specially trained to handle such cases in a sensitive and appropriate manner.

Within the 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 a remedial measure or penalty. The purpose of the hearing team is to learn, to the best of its ability, the truth from all parties to the charge. 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

Except in extreme cases (where discretionary responsibility has been retained by the president or a delegate), no student shall be expelled or suffer other disciplinary action for nonacademic misconduct unless the judicial officer takes summary disciplinary action (interim sanction pending a hearing) or unless the student has gone through a hearing. However, a student or group may waive any disciplinary hearing after consultation with the judicial officer, who will implement an appropriate sanction.

*For the School of Nursing, consult the School of Nursing Handbook.
Fundamental fairness for disciplinary hearings at the University consists of the following standards:

1. All charges must be in writing and presented to the student 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 student shall be informed of his or her rights at the time he or she is charged and in his or her preliminary meeting with the judicial officer.
4. The accused shall be afforded one day to decide if he or she wishes to have a hearing.
5. The accused 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 has been selected; however, the judicial officer may extend time lines to accommodate academic calendar or other extenuating circumstances.
7. All hearings are closed.
8. The accused 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 may be any 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 Office of the Dean of Students in the College.
9. Both the accused and the judicial officer have the right to request that the hearing be recorded. A recording of the hearing will be available in the event of an appeal, but remains the property of the University.
10. The accused shall have the opportunity to answer accusations and to submit the testimony of material witnesses on his or her own behalf.
11. All evidence and testimony, including the relevant security reports, the text of statements made by the accused prior to his or her hearing and used at the hearing, and any physical evidence shall be presented in the presence of the accused; however, legal rules of evidence shall not apply.
12. Relevant reports, documents, and other evidence may be reviewed by the accused in the Office of the Dean of Students prior to the hearing. Copies of any such material may not, however, leave the office.
13. The accused shall have the opportunity to indirectly question (through the hearing teams) all witnesses. This does not necessarily include the right to confront witnesses in person.
14. The accused and all other participants are expected to fully cooperate in the hearing. However, the accused has the right not to take the oath. In such a case a violation of University policy may nevertheless be found based on the other evidence presented. If the oath is not taken, the accused may ask questions of the witnesses and may summarize the testimony of the witnesses, but may not describe the incident.
15. The hearing teams shall determine by a majority vote whether it is more likely than not (i.e., by a preponderance of the evidence) that the accused violated a University policy, rule, or regulation.
16. The findings and recommendations of any of the hearing teams will be forwarded to the judicial officer. In the event the judicial officer does not accept the findings or recommendation of a hearing team, he or she may request further consultation and review by the hearing team or may make a different finding or recommendation if warranted by the evidence presented at the hearing. The judicial officer will notify the accused in writing of the hearing team’s findings/recommendations and of his or her decision and sanctions, if any.

17. The accused has the right to appeal a final decision in a nonacademic case to the appropriate dean/director and in an academic case to the provost.

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

**Victim’s Rights**

In all cases, charges are brought by the University against a student accused of an offense; in many cases, the University is in fact the only identifiable “victim” of an alleged offense. However, there are cases in which there is an identifiable “victim” other than the University. When the judicial officer determines that a victim can be identified, the victim is entitled to the following:

1. He or she may be present to hear all testimony, indirectly question witnesses (through the hearing teams), and may be accompanied by an advisor who may confer with and assist the victim but may not speak for him or her as an advocate. The advisor may be any member of the University community who is not an attorney;
2. He or she is entitled to learn the final outcome of the case;
3. He or she will be given an opportunity to make a victim impact statement which will become part of the case record to be reviewed by the judicial officer in any decision/sanction and by any dean or director considering an appeal; and
4. He or she may request separate hearing rooms (connected electronically) in order to allow full participation of the parties while at the same time avoiding undue embarrassment or intimidation.

**SANCTIONS**

Maintenance of community standards is an important component of the judicial process. A major goal of the disciplinary 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 impose a penalty that will best educate the student or group involved. One or more of the following sanctions (or any combination) may be implemented when students or groups have been found in violation of University regulations. The following list is not exhaustive and other sanctions may be imposed at the discretion of the judicial officer.
1. 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.

2. 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.

3. 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.

4. Revocation or Restriction of Privileges for the use of designated University facilities or programs.

5. 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.

6. 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 if specified.

7. 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.

8. Suspension, which generally involves the revocation of the privilege of attending the University and using its facilities for a certain period of time. Conditions for re-entry may be specified.

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

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 disciplinary hearing. The only grounds on which an appeal can be made are:

1. To review the punishment in order to determine whether it was appropriate;

2. To consider information sufficient to alter the decision that was not available at the time of the disciplinary hearing; or

3. To determine whether errors substantive enough to affect the decision were made during the hearing.
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 disciplinary decision. The letter must state the grounds on which an appeal is made and what the appellant 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. At the discretion of the dean/director or provost and upon the recommendation of the judicial officer, where appropriate, all or some of the sanctions may be suspended pending the final decision.

DISCIPLINARY RECORDS

Student records, including files from disciplinary cases maintained by the University, are treated with appropriate confidentiality, in accordance with the University policy on student records and relevant legal standards. Academic transcripts issued during periods of suspension or expulsion will be accompanied by a letter from the registrar indicating that the student is currently suspended or expelled from the University for disciplinary reasons. Officers of the University who have knowledge of disciplinary action 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. Disciplinary files are normally destroyed five years after the student’s graduation or other separation from the University. However, certain University officials may retain indefinitely a record of offenses and final dispositions (without the names of the participants) to provide a precedent to assist the adjudication of future cases.

ACADEMIC MISCONDUCT

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 for graduate studies.

A common form of academic dishonesty is plagiarism. 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 you could not or did not have.
not arrive at on your own. Sources must be given regardless of whether the material is quoted directly or paraphrased. Another form of plagiarism is the 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 knowingly falsify data or data analysis results or assist someone else in an act of academic dishonesty.

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 or the degree is granted. This rule applies to students who are no longer matriculated at the University of Rochester, including those who have graduated.

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

JUDICIAL PROCESS FOR ACADEMIC MISCONDUCT

As indicated in the diagram on page 51, charges of academic misconduct are referred to the student’s department by the associate dean. In a school or college without departments, these matters will be handled by the school or college. Each department, interdisciplinary program, or college 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 who 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.
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.

- 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

- Case dismissed

- Informal or administrative resolution
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 above.

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.

HARASSMENT AND DISCRIMINATION

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 information and ideas.

To help establish and perpetuate an inclusive and open environment, all members of the University community shall adhere to and advance the University’s Equal Opportunity Statement:

The University of Rochester values diversity and is committed to equal opportunity for all persons regardless of age, color, disability, ethnicity, marital status, national origin, race, religion, sex, sexual orientation or veteran status, or any other status protected by law. Further, the University complies with all applicable nondiscrimination laws in the administration of its policies, 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, University of Rochester, P.O. Box 270039, Rochester, NY 14627-0039. Phone: (585) 275-9125.)—See HR Policy 100

Any behavior, including verbal or physical conduct, that constitutes discrimination against or harassment of any member or guest of the University community in any form is prohibited.

Retaliation in any form against a person because he or she complained about an act of discrimination or harassment is prohibited.

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.

Sexual Assault

The University has established procedures to insure that consistent supportive care of rape and sexual assault victims is provided. Numerous resources are available, including the 24-hour sexual assault hot line (275-7273), Campus Security (275-3333, x13 for emergencies), University Counseling Center (275-3113), University Health Service (275-2662), and the intercessor for
sexual harassment (275-9125). The Office of the Dean of Students (275-4085) is responsible for handling campus judicial procedures dealing with sexual assault and sexual harassment. (See “UR Here” available from the Office of the Dean of Students.)

GRADUATE DEGREES

DOCTORAL DEGREES

The University offers the degrees of Doctor of Education, Doctor of Medicine, Doctor of Musical Arts, and Doctor of Philosophy.

The requirements for the degree of Doctor of Philosophy are described in the sections which follow. Requirements for the degree of Doctor of Education can be obtained from the Margaret Warner Graduate School of Education and Human Development (see www.rochester.edu/Warner); for the degree of Doctor of Medicine, the School of Medicine and Dentistry, see www.urmc.rochester.edu/smd; and for the degree of Doctor of Musical Arts, the Eastman School of Music, see www.esm.rochester.edu.

DOCTOR OF PHILOSOPHY DEGREE

The degree of Doctor of Philosophy is awarded primarily for completion of scholarly work, research, or outstanding creative work satisfactorily described in a dissertation. It is assumed that recipients of this degree are well versed in the subject matter and research techniques of a specific discipline and have demonstrated breadth of interest and originality of outlook that indicate promise of success in future research and teaching.

The amount of background knowledge and degree of technical skill required for entrance into programs leading to the degree of Doctor of Philosophy vary greatly, both with the subject of specialization and with the objectives of the candidate. Because of this variation, there are very few requirements for the degree applicable to candidates in all departments. Each candidate is personally responsible for satisfying not only these general requirements but also any specific requirements imposed by the candidate’s department or division of the University.

Joint or Interdisciplinary Doctor of Philosophy Degrees

Departments/programs authorized to offer work leading to the Ph.D. degree also may cooperate to offer work toward the degree on an interdepartmental basis. Joint work is supervised by an ad hoc committee for a single 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 college or colleges in which the departments/programs are located. A proposal outlining how degree requirements will be fulfilled 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.
For a continuing formalized interdisciplinary program (i.e., Visual and Cultural Studies, Neuroscience), a standing committee acts as a “department” and supervises the program requirements for its students.

**Administration of Work for the Degree Doctor of Philosophy**

Each school and college of the University has a Committee on Graduate Studies 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 or college with respect to requirements and training for the Ph.D., and advising the associate dean for graduate studies about the work toward the Ph.D. degree.

In addition to the Graduate Committee of each school and college, there is a University Council on Graduate Studies composed of representatives of departments and programs in the University authorized to offer the Ph.D. degree, the dean and the associate dean for graduate studies of each school or college, the director of Research and Project Administration (ex officio and without vote), the provost of the University, and the University dean of graduate studies, who serves as chair.

The principal functions of the council are

1. 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 avail itself of the services of scholars from other universities who may be appointed for short terms as “visitors.”
2. To decide on the basis of quality considerations which departments shall be authorized to give work towards the Ph.D. degree, and to authorize or restrict, as necessary, the different Ph.D. programs within a department.
3. Upon nominations by the faculties or other authorized agencies in the several schools and colleges, 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 and associate dean for graduate studies of each college, advises the council in the performance of its functions.

The University dean of graduate studies presides at meetings of the council and the Steering Committee; is the University spokesperson in matters of graduate studies; serves ex officio as a member of the committee established in any college for the conduct of the M.A., the M.S., or the Ph.D. degree; and appoints (upon the advice of each associate dean for graduate studies) all committees for the final oral examination for the Ph.D. degree. The University dean of graduate studies, or a representative of the University dean, presides at all such examinations as chair.
Regulations for the Degree Doctor of Philosophy

Admission

Admission to graduate studies in any department/program must be recommended by the chair of that department, program director, or a designated representative and approved by the associate dean for graduate studies. Admission to a graduate degree program at the University of Rochester is for that program alone. Admission to any other program requires a completely new admissions application.

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 reflects the completion of a separate Doctor of Philosophy or other appropriate advanced graduate degree. Faculty members of the rank of instructor and 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. Such permission does not constitute a waiver of the rule stated in the first sentence of this paragraph.

Transfer Credit*

Of the University’s minimum required 90 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. All transfer hours, whether taken at the University of Rochester or at another university, must be approved by the associate dean of graduate studies.

Work taken prior to matriculation in a graduate degree program is classified as possible transfer work. Up to the 30-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. Requests for transfer credit must have the approval of the associate dean for graduate studies.

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 for graduate studies.

Full-Time Residence

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

Students who register for at least 12 hours of credit for a semester, and graduate assistants and other students doing work essentially equivalent to that of an assistant who register for at least 9 hours of credit for a semester, are full-time students in graduate studies, as are advanced students registered for “999: doctoral dissertation.” Students, who during the academic year have been full-time graduate students as defined above, are classified as full-time during the summer. Students enrolled for the summer, even though the number of credit hours for which they are registered may be less than that otherwise defined as full time, are

* Credit hours used for two graduate degrees cannot be used for another graduate degree at the University.
also classified as full time. Students in residence but not registered for summer credit may register for “990: doctoral summer in residence.”

A minimum of one year (two consecutive semesters, excluding summers) in residence and enrollment as a full-time student is required.* 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.

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 for 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 preceding section on Transfer Credit).

A doctoral student who has completed at least 90 credit hours of graduate credit beyond the bachelor’s degree, or at least 60 hours beyond an accepted master’s degree, or more if required in their doctoral program, will be considered to have fulfilled the credit-hour requirements for the Doctor of Philosophy degree as stated above. Such a student may continue in residence as a doctoral candidate and hold a graduate student appointment with the approval of the associate dean without being required to register for a full-time program of study. If additional work for graduate credit is necessary to complete the program, the student must register formally, and tuition and fees will be charged. If, however, all work except writing the dissertation is completed, the student will register, with the advisor’s approval, for “999: doctoral dissertation,” and will not be subject to the usual tuition charges, but will be charged the designated fee for this registration as well as all required health fees. Upon written request and with the prior approval of the associate dean for graduate studies, “999” registration may be elected by eligible candidates not in residence who are entitled to full-time student status.

Ordinarily, research in preparation for the dissertation must be completed while the student is in full-time residence at the University of Rochester. Occasions may arise that demand this research be performed and the dissertation be written elsewhere. Such occasions may arise, for example, from the availability of source material and consultation with authorities in the field of interest. Permission to do work for credit in absentia must be obtained in advance from the associate dean for graduate studies after recommendation by the student’s department/program. Permission also may be granted to complete the dissertation while not in residence as a full-time student if the appropriate conditions are met and the student registers for “995: continuation of doctoral enrollment.”

Part-Time Residence

In certain cases a department may decide that it is not feasible for a student to pursue all of the work for the Ph.D. degree on a full-time basis and may recommend a special Ph.D. program in which some of the work is on a part-time basis. The setting up of such a special plan of study is at the option of the department/program, subject to the approval of the Committee on Graduate Studies of that college. (In the School of Nursing, part-time admission and program plans are

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* Doctoral Dissertation (“999”) may not be used to fulfill the one-year residency requirement.
approved by the Doctoral Program Director.) If the plan is approved, the department/program may recommend the admission of students to work toward the Ph.D. degree under this plan, subject to the following restrictions: (1) under no conditions will the requirement 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 this special program.

Time Limit*

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

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 Ph.D. 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 for graduate studies. Each student should consult with his or her advisor concerning language requirements.

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

Program of Study†

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:

1. A list of those courses for which the student must receive graduate credit. Other courses deemed to be desirable but not essential need not be listed.
2. The specific foreign language(s), if any, in which the student must show competence (see section above).
3. The dissertation title if possible, but otherwise the area of study in which the dissertation is expected to be written, and the 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 for approval. The program, approved by the associate dean (in the School of Nursing, the doctoral program coordinator), will constitute the formal requirements

* All registration categories, including “985: Leave of Absence,” count towards the time limit.
† Credit hours used for two graduate degrees cannot be used for another graduate degree at the University.
which will be met by the student before completion of work for the degree. Changes in the program are made by the same procedure as for new programs.

Qualifying Examination

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 at least three-fourths 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. A second qualifying examination after failure, if permitted, may be taken after a period of five calendar months. 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 (in the College, approval from the dean of graduate studies is sufficient; in the School of Nursing, a third examination will not be given).

Admission to Candidacy

When the associate dean of a school or college 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 Ph.D. degree. Upon request, the University dean of graduate studies may issue a certificate attesting to this fact.

Dissertation Advisory Committee

At an appropriate time, ordinarily no later than when a student has been admitted to candidacy, the department chair/program director must approve an advisory committee for the dissertation typically consisting of at least the following persons of assistant professor rank or higher: the faculty advisor or research director (who shall be a full-time member of the University faculty), at least one other full-time faculty member from the student’s department/interdisciplinary program, and a full-time faculty member from another department or academic unit. The composition of the dissertation advisory committee should be reported to the associate dean.

Upon recommendation of the faculty of the student’s department/program and the associate dean of the college 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

* Seven months in the College: Arts and Sciences
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.

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 serve on the final oral examination committee.

Dissertation*

A dissertation is required of each candidate for the degree Doctor of Philosophy. The dissertation must be an original critical or synthetic treatment of a fitting subject, an original contribution to creative art, or a report on independent research formulated in a manner worthy of publication.

Ordinarily, the dissertation is written in residence. However, this rule will not be interpreted to forbid the completion of the dissertation while the student is not in residence if during such a period the research director is able to maintain close supervision over the work. Such arrangements, which must have the associate dean’s approval before they are undertaken, do not exempt the student from the responsibility of paying two full years of tuition beyond the time that he or she receives the master’s degree or three full years beyond the bachelor’s degree.

If a candidate for the degree Doctor of Philosophy has collaborated with others in carrying on the research upon which the dissertation is based, the character and extent of the candidate’s own participation in the project must be stated clearly in a foreword to the dissertation.

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 for graduate studies.

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

Final Oral Examination Committee

The dissertation advisor or supervisor is a member of the final oral examination committee and must be present for the examination.

The committee for the final examination for the Doctor of Philosophy degree is appointed by the University dean of graduate studies on the advice of the appropriate associate dean for graduate studies. The committee shall consist of at least two current full-time faculty members of the rank of assistant professor or higher who hold their primary appointment in the candidate’s major department and one current full-time faculty member, assistant professor or higher, with a primary appointment in a department other than the candidate’s major department (usually referred to as the outside reader).† Some departments require the appointment of an additional faculty member to the committee; check with the appropriate associate dean’s office. The holder of a secondary appointment in the

* “The Preparation of Doctoral Theses: A Manual for Graduate Students” must be followed to prepare the dissertation. Copies are available from the University dean’s office, associate deans’ offices, departmental offices, or the University’s Web site: www.rochester.edu/theses.

† If the dissertation advisor holds his/her primary appointment in a department other than the candidate’s major department, the dissertation advisor cannot also serve on the committee as the required outside reader.
candidate’s major department may serve as the outside member, provided that his or her primary appointment is in another department.

For authorized interdisciplinary programs (Neuroscience, Visual and Cultural Studies, etc.), the committee shall consist of at least two current full-time faculty members of the rank of assistant professor or higher from the defined list of core faculty for the program, and one current full-time faculty member, assistant professor or higher, who is not a member of the program core faculty. Some programs require the appointment of an additional faculty member to the committee; check with the appropriate associate dean’s office. A committee made up of faculty members whose primary appointments are all in the same department will not be permitted.

The University dean of graduate studies may appoint no more than one guest member, with vote, to any Ph.D. final examination when requested by the program director or chair of the department concerned. 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. The guest member may either replace or be in addition to the usual outside reader. A request to the University dean of graduate studies must include a curriculum vitae and must first be approved by the associate dean of graduate studies in the relevant college before being forwarded to the University dean of graduate studies.

The final oral examination committee is presided over by the University dean of graduate studies or an appointed representative, who serves as chair.

In addition to the members of the examining committee, other persons may attend the closed portion of Ph.D. final examinations with the approval of the department chair/program director, and also the presiding chair of the examining committee. Such visitors shall not participate in the questioning unless given permission by the presiding chair of the examining committee, and must leave before the committee votes.

Registering the Ph.D. Dissertation for the Final Oral Examination

It is the responsibility of the candidate to submit the completed dissertation in FINAL FORM* to the Office of the Associate Dean for Graduate Studies in the appropriate college by his or her deadline, 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. The dissertation will not be accepted for registration if the candidate is not registered for the current semester/quarter. The dissertation will not be accepted for registration until the microfilming fee is paid to the bursar and the microfilming form is filled out and signed.

It is the responsibility of the candidate to distribute copies of the dissertation to members of the committee appointed to conduct the final oral examination 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

* Final Form: All typographical, spelling, and grammar errors must be corrected before the dissertation is submitted for registration. A final “draft” (which includes numerous errors to be corrected after the defense) is not acceptable.
committee members, no further changes can be made until after the final oral
examination or the examination will be canceled.

The dissertation must be submitted to the Office of the Associate Dean
for Graduate Studies in the appropriate college in sufficient time for it to be
processed and then delivered to the Office of the University Dean of Graduate
Studies. The dissertation is not considered registered until it arrives in the Office
of the University Dean of Graduate Studies.

If approved by the associate dean of graduate studies, the dissertation must
then arrive in the Office of the University Dean of Graduate Studies a MINI-
MUM OF 15 FULL WORKING DAYS prior to the scheduled final oral exa-
mination.* Note that the deadline of 15 full working days is for registration of the
dissertation in the Office of the University Dean of Graduate Studies. Prior to
that, the dissertation must be approved by the department and the appropriate
college associate dean of graduate studies. Therefore, the department and/or col-
lege deadline may include days in addition to the University dean of graduate
studies’ deadline. It is the student’s responsibility to plan accordingly. The stu-
der should check with his/her department and with the Office of the Associate
Dean for Graduate Studies for established deadlines. See the section below (Final
Oral Examination) for additional information.

Final Oral Examination

A final oral examination will be taken after completion of all other require-
ments for the degree but not earlier than six months after the qualifying exami-
nation (seven months in the College: Arts and Sciences).

The final oral examination for the degree Doctor of Philosophy cannot be
held until AT LEAST 15 FULL WORKING DAYS have elapsed after the dis-
sertation has been registered in the Office of the University Dean of Graduate
Studies.*

No final examination for the degree Doctor of Philosophy can be held during
certain specific periods listed in the Ph.D. calendar established by the Office of
the University Dean of Graduate Studies. Final oral examinations for the Ph.D.
degree may be scheduled by the normal procedure during the summer according
to the Ph.D. calendar. Examinations are permitted only in very special circum-
cstances and by approval of the University dean of graduate studies during nonex-
amination (blackout) periods.

The final oral examination for the Doctor of Philosophy degree must be
taken at this University. A candidate may proceed with the final oral exami-
nation only after receiving written permission of the advisor of the dissertation.

The final oral examination will include the subject covered by the disser-
tation and the special field in which the dissertation is written, with particular
attention to the more recent and significant developments in that field. The pur-
pose of the final oral examination 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 presenta-
tion and defense of a significant dissertation is the capstone of the work for the

* The University dean of graduate studies’ deadline of 15 full working days may be increased to 20 full working days
during the summer Ph.D. final oral examination period.
Ph.D. degree. Everything else is a preliminary for this presentation. Courses are intended to prepare the student for work on the dissertation, and the qualifying examination is intended to ascertain whether or not the preparation is adequate. In a sense then, the final oral examination results not only in an explicit judgment of 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 and provided such repeat examination is held in such a way as to conform with regulations for the initial examination.

Following successful completion of the final oral examination and any additional minor revisions, two permanent paper copies (one for the School of Medicine and Dentistry and the School of Nursing) of the corrected dissertation, unbound and without perforations are to be presented to the Office of the University Dean of Graduate Studies for permanent deposit in the University library system. (Candidates in the School of Medicine and Dentistry are to present their dissertations to the office of their associate dean for graduate studies.) The candidate should prepare a copy for personal use and such other copies as may be required by the department in which the work was done.

In addition to the final paper copies, all Ph.D. students are also required to submit one complete copy of their dissertation in digital/electronic format along with a completed authorization form. Further instructions along with the authorization form will be given to each student at his or her final oral examination.

The dissertation need not be published, but the dissertation will not be approved if it is subject to governmental or other restrictions which limit freedom of publication. If published in full or in part, or if the substance of a dissertation is published, a statement that the publication is based upon the dissertation must be included in the publication.

MASTER OF ARTS AND MASTER OF SCIENCE DEGREES

The master's degree is awarded in arts, science, music, engineering, nursing, business administration, and education. The administration of work for the master's degrees is vested in the associate dean for graduate studies and the Committee on Graduate Studies in each school or college. The University dean of graduate studies is authorized to appoint a committee to review the M.A. or M.S. program in any department of the University at appropriate intervals, but at least once every 10 years.

Two plans of study are available to students working for these master's 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 for graduate studies.

**General Requirements for the Degree**

The requirements for some Master of Arts and Master of Science degrees can be fulfilled in one academic year (two semesters) wholly devoted to advanced study. In other cases, one and one-half or two years of study may be required to complete requirements. Students whose preparation is deficient upon admission will find it necessary to devote proportionately more time to completing their master's programs.

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 for graduate studies.

**Maximum Time***

A candidate must complete all the requirements for the master's degree within five years from the time of initial registration for graduate study, and must maintain continuous enrollment for each term after matriculation. Except for 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.

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 for an extension of time. Such extension, if granted, will be of limited duration.

**Part-Time Study**

Students admitted for master's degrees on a part-time basis must follow continuous programs of study. The associate dean for graduate studies may disapprove a part-time program if the nature of the proposed study makes such a program inadvisable.

**Program of Study†**

Each full-time master's student must submit a proposed program of study to the associate dean for 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 or college. 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 in residence at the University of Rochester as a matriculated student in a

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* All categories including “Leave of Absence” count towards the time limit.
† Credit hours used for two graduate degrees cannot be used for another graduate degree at the University.
graduate degree program. Ordinarily, no course completed before the candidate has received the bachelor’s degree may be included in the graduate program.

Transfer Credit†

Of the University’s minimum required credits 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 credit, whether taken at the University of Rochester or at another university, must be approved by the associate dean for graduate studies.

Work taken prior to matriculation in a graduate degree program is classified as possible transfer work. Up to the 10-credit-hour limit for transfer 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 for graduate studies.

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 for graduate studies.

Credit for Reading Courses

The amount of graduate credit allowed for independent study and single-student reading courses may not exceed a total of six hours, except with the special permission of the associate dean for graduate studies obtained before such additional courses are begun. Students registering for a reading or independent study course must submit at the time of registration a brief description of the subject to be covered. This description must be signed by the instructor conducting the course and filed in the Office of the Associate Dean prior to registration.

Requirements for the Degree Under Plan A

Plan A requires the writing of a dissertation and the passing of an oral examination on the dissertation.

Dissertation

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 certain cases, and with the prior approval of the associate dean for graduate studies, the credit for dissertation research may exceed 12 hours.

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.

† Credit hours used for two graduate degrees cannot be used for another graduate degree at the University.
“The Preparation of Doctoral Theses: A Manual for Graduate Studies” is also used to prepare master's dissertations. Copies of the booklet are available from the Office of the Associate Dean for Graduate Studies or on the University's Web site: www.rochester.edu/theses.

Registration
The dissertation must be registered with the Office of the Associate Dean for 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 for graduate studies.

Number of Copies
If the dissertation is accepted by the student’s examining committee, two permanent unbound copies (one for the School of Medicine and Dentistry and the School of Nursing) must be presented to the Office of the Associate Dean for Graduate Studies for deposit in the University library system. The candidate should prepare such other copies as may be required by the department in which the work is done.

Final Oral Examination
Each candidate must pass a final oral examination before a committee of at least three members of the faculty appointed by the associate dean for 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 may be designated by the department/program or college 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 college.

Requirements for the Degree Under Plan B
In most departments/programs Plan B requires a comprehensive examination in lieu of a master's dissertation, but credit up to a maximum of four hours may be given for writing a master's essay.

Program of Study
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 college 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 colleges may set higher requirements.
A student in the Margaret Warner Graduate School of Education and Human Development who has had prior professional study (a minimum of 18 semester hours of undergraduate or graduate courses in education) may develop a program which has 12 semester hours of professional study and 18 semester hours in appropriate academic subjects. 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 for graduate studies, up to six hours of research credit may be granted. Total credit for research and the master's essay may not exceed six hours.

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, but 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 departments/programs require a general examination on the field of specialization. It is conducted by at least two faculty members.

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

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 www.simon.rochester.edu.
3. 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.
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Govind S. Mudholkar, Ph.D. (North Carolina) . . . Professor of Statistics and of Biostatistics
Carl Mueller, Ph.D. (California, Berkeley) . . . Professor of Mathematics
John S. Muenter, Ph.D. (Stanford) . . . Professor of Chemistry
Paul Muller-Ortega, Ph.D. (California, Santa Barbara) . . . Professor of Religion
Raymond Murphy, Ph.D. (Northwestern) . . . Professor Emeritus of Sociology
Joseph Neisendorfer, Ph.D. (Princeton) . . . Professor of Mathematics
Elissa Newport, Ph.D. (Pennsylvania) . . . George Eastman Professor of Brain and Cognitive Sciences and Professor of Psychology
Richard G. Niemi, Ph.D. (Michigan) . . . Don Alonzo Watson Professor of Political Science
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Kathy W. Nordeen, Ph.D. (California, Irvine) . . . Professor of Brain and Cognitive Sciences, of Psychology, and of Neurobiology and Anatomy
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Mitsunori Ogihara, Ph.D. (Tokyo Institute of Technology) . . . Professor of Computer Science
Walter Oi, Ph.D. (Chicago) . . . Professor of Economics
Susumu Okubo, Ph.D. (Rochester) . . . Professor Emeritus of Physics
Joanna Olmsted, Ph.D. (Yale) . . . Professor of Biology
H. Allen Orr, Ph.D. (Chicago) . . . Professor of Biology
Lynne H. Orr, Ph.D. (Chicago) . . . Professor of Physics
Dorinda Ostrum, Ph.D. (Cambridge) . . . Franklin W. and Gladys I. Clark Professor of History
Gary D. Paige, M.D. (Chicago) . . . Kilian J. and Caroline F. Schmitt Professor of Neurobiology and Anatomy, Professor of Neurology, of Ophthalmology, of Biomedical Engineering, of Surgery, of Brain and Cognitive Sciences, and in the Center for Visual Science
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Tatiana Pasternak, Ph.D. (Copenhagen) . . . Professor of Neurobiology and Anatomy, of Brain and Cognitive Sciences, and in the Center for Visual Science
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Arnold Pizer, Ph.D. (Yale) . . . Professor of Mathematics
Terry Platt, Ph.D. (Harvard) . . . Professor of Biology and Adjunct Professor of Biochemistry and Biophysics
Charles I. Plosser, Ph.D. (Chicago) . . . John M. Olin Distinguished Professor of Economics and Public Policy in the William E. Simon Graduate School of Business Administration and Professor of Economics
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Lenhart Schubert, Ph.D. (Toronto) . . . Professor of Computer Science
Jerome S. Schwartzbaum, Ph.D. (Stanford) . . . Professor Emeritus of Psychology
Joanna Scott, M.A. (Brown) . . . Roswell S. Burrous Professor of English
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Sanford L. Segal, Ph.D. (Colorado) . . . Professor of Mathematics and of History
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Mark Fey, Ph.D. (California Institute of Technology) . . . Associate Professor of Political Science

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Priscilla Auchincloss, Ph.D. (Columbia) . . . Senior Lecturer in Physics
John Bennett, Ph.D. (Michigan) . . . Senior Lecturer in Philosophy
Alan Dietsche, Ph.D. (Kentucky) . . . Senior Lecturer in Biology
Monica Florence, B.A. (Reed) . . . Senior Lecturer in Classics
Lisa Johnston, M.A. (Arizona) . . . Senior Lecturer in American Sign Language
Nigel Maister, M.F.A. (Carnegie Mellon) . . . Senior Lecturer in English
Anna Maslenikova, Ph.D. (St. Petersburg) . . . Senior Lecturer in Russian
Anthony Olek, Ph.D. (SUNY, Albany) . . . Senior Lecturer in Biology
Deborah Rossen-Knill, Ph.D. (Minnesota) . . . Senior Lecturer in English
S. Linn Sadjak, Ph.D. (Wisconsin, Milwaukee) . . . Senior Lecturer in Biology
Deirdre Schlehofer, M.Phil. (Bristol) . . . Senior Lecturer in American Sign Language
Curtis Smith, B.A. (SUNY, Geneseo) . . . Senior Lecturer in English
Mariko Tamate, Ph.D. (Meiji) . . . Senior Lecturer in Japanese
Michael Wolkoff, Ph.D. (Michigan) . . . Senior Lecturer in Economics

ADMISSION REGULATIONS

Applicants for admission to graduate work must satisfy 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 for advanced degrees. All applicants for admission must present evidence that, exclusive of introductory courses, they have completed not less than 18 credit hours of college work of high standing in their principal subject of study, or a satisfactory equivalent. Students with good undergraduate records which do not include 18 hours of credit in the field of their choice may be admitted as special students to complete prerequisites prescribed by the department. Preparation in related subjects must be satisfactory, and applicants may be required to have a reading knowledge of those languages essential to the literature of their fields of study. Undergraduate programs should give evidence that students have taken introductory work in the arts, social studies, and sciences.
SPECIAL REGULATIONS

1. To be assured credit for graduate work, admission to graduate studies should precede any work done at the University of Rochester which is to be applied toward the master’s or Ph.D. degree. A maximum of one course taken as a nonmatriculated student may be approved for use in the graduate program for matriculated graduate students.

2. All students entering Ph.D. graduate studies in the arts and sciences at the University of Rochester must take the qualifying examination 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 request for an exception to this regulation should be made before the end of the fourth semester of graduate study. A department may require the student to take the qualifying examination before the stated time limits. Seven months must elapse between the qualifying examination and the final oral examination (thesis defense).

3. Part-time master’s candidates must file a proposed complete program of study upon the completion of 12 hours of graduate credit.

4. Students on probation must complete 12 semester hours of graduate credit with no grade lower than B– before being admitted to full standing. If they receive any grade lower than B–, their enrollment in graduate studies is automatically terminated. In special cases this may be reviewed by the dean of graduate studies.

5. 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 have been adjusted to eliminate the excess. In special cases, this may be reviewed by the dean of graduate studies.

6. 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 College Dean for 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. The official transcript will show only the final grade the instructor assigns.

7. By action of the Committee on Graduate Studies, the following departmental Ph.D. 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.

8. 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, and satisfactory performance on a comprehensive examination in the student’s field of specialization.
qualifying examination for the Ph.D. degree may be substituted, and the examination may be written or oral or both. Of the required 30 hours, at least 18 of these hours must be in the student’s principal department, and at least 24 hours in the approved master’s program must be in courses numbered 400 or more. 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 over. It may carry up to 4 hours of credit.

9. M.A. or M.S. degrees in interdepartmental studies within fields of study in arts and sciences 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 College 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 are concerned. It may also be helpful to review programs at other universities, which may be similar to the ones they are planning. Initial inquiries should be directed to the Graduate Studies Office in 218 Lattimore Hall. Staff in the GSO will respond to general inquiries, explain the procedures of the application process, and refer potential candidates to the relevant departments and/or faculty members. Students should have transcripts or a list of completed courses for review with each potential advisor. This will be helpful in shaping students’ programs.

The College Application for Graduate Admission and Financial Aid should be completed and Parts I and II should be submitted to the GSO with the proposal. The recommenders should send reference reports directly to the GSO.

**Biology**

Professors Eickbush, Goldfarb, Jaenike, Olmsted, Orr, Platt, Werren
Associate Professors Benyajati, Fry, Sia
Assistant Professors Bi, Glor, Gorbunova, Jasper, Lambert, Miller, Presgraves, Ramsey
Assistant Professor (Research) Seluanov
Joint Appointments: Associate Professor Jiang
Professors Emeriti Bannister, Gorovsky, Hall, Hattman, Hinkle, Hoch, Kaye, Muchmore, Nur

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

**PH.D. 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 Ph.D. research in the laboratory of a chosen faculty member at the end of the first year.

Admission to candidacy for the Ph.D. 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 Ph.D. 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 Ph.D. 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.

M.S. 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 M.S. 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 M.S. 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 B.S. or B.A. 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: introductory course in genetics is recommended.

This course deals with the molecular mechanisms of gene replication, gene expression, and the control of gene expression in both prokaryotic and eukaryotic cells. Topics include enzymatic mechanisms of DNA replication, recombination and repair; transposable elements; DNA transcription; RNA splicing; RNA translation; repressors, activators, and attenuators; recombinant DNA and genetic engineering.

405. Evolution
Prerequisites: introductory courses in biology and genetics.

Fundamentals of evolution and population genetics. Topics include origin of biological variation, natural selection and its ecological basis, population genetics including selection and drift. Molecular evolution and speciation are also covered.

420. Advanced Cell Biology: Cytoplasmic Structures and Functions
Prerequisites: introductory courses in genetics and cell biology are recommended.

An advanced-level discussion of the organization and function of cytoplasmic organelles. Lectures and readings are from original research literature. Emphasis is on the analysis and interpretation of experimental results. Topics include protein trafficking, cell motility and morphogenesis, cell cycle, cell death, and cancer.

422. Biology of Aging
Prerequisite: none.

This course focuses on molecular mechanisms of aging and its relation to DNA damage and repair. Evolution of aging, model organisms used in aging research, human progeroid syndromes, and interventions to slow aging are discussed.

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 fertilization, cloning (of embryos), embryonic cleavage, gastrulation, early development of model vertebrates and invertebrates, patterning of cell fates along embryonic axes of Drosophila and vertebrates, organogenesis, sex determination, and stem cells.

428. Laboratory in Cell and Developmental Biology
Prerequisites: introductory courses in cell and developmental biology or permission of the instructor.

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

432. Genetic Diversity and Human Diseases
Prerequisite: introductory course in genetics.

Examines genetic diversity in human populations from an evolutionary perspective, with particular attention to inherited diseases and disease-related traits. Covers single gene disorders, chromosome abnormalities, and diseases with complex inheritance. Topics include mapping and cloning disease genes, evolutionary determinants of frequencies of disease genes in populations, and using genetic information to reconstruct human migrations and evolution. Class time is evenly divided between lectures and discussions based on readings in the primary literature.

IND 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.

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 basic 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.

468. Laboratory in Molecular Genetics
Prerequisite: introductory course in molecular biology.

A series of experiments, each lasting two or three weeks, introducing various organisms and techniques. Current experiments include a yeast two-hybrid screen for interacting proteins, construction and confirmation of a yeast gene "knock-out," purification and analysis of Drosophila DNA, mapping a gene in zebrafish using microsatellite markers, and purification and characterization of an affinity-tagged protein.

472/473/474. Topics in Ecology and Evolution
Prerequisite: none.

These courses explore contemporary topics in ecology and evolutionary biology.

480. Graduate Laboratory Rotation
Prerequisite: normally restricted to Ph.D. 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.

584. Seminar in Evolution

Brain 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 230.

Brain and Cognitive Sciences

Professors Aslin, Chapman, Ison, Jacobs, Kellogg, Knill, Lennie, Makous, Newport (Chair),
E. Nordeen, K. Nordeen, Tanenhaus, Williams
Associate Professors Bavelier, Pouget, Supalla, Weliky
Assistant Professor Jaeger
Joint Appointments: Professors Allen, Carlson, Duffy, Haber, Klorman, Merigan, Paige, Pasternak, Schieber; Associate Professors Como, McDonough, Mink, O'Neill, Runner

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 Ph.D. 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 Ph.D. 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 Ph.D. 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 may be asked to serve as teaching assistants for one course each year during tenure of their fellowships, but in recent practice the load has been less than this. 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 substrate 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 to Brains
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.
519. Instrumentation and Methods for Vision Research

This course describes the design, construction, and operation of optical instrumentation used in modern vision research. We discuss techniques to deliver visual and auditory stimuli and to measure visual performance in human subjects, animal subjects, and single neurons. Examples of topics covered include display calibration, light measurement, computer control of experiments, eye tracking techniques, virtual environments, and brain imaging.

Advanced Seminars in Perception

521. Audition

Examines the physiological substrate responsible for hearing. Topics include the physical stimulus for hearing, receptive aspects of speech and language, peripheral physiology (the outer and middle ears, cochlea, and auditory nerve), and central physiology (brainstem nuclei, auditory cortex, descending systems). Introduces electrophysiological techniques used to study auditory function, and explores sensory and perceptual correlates of physiology and sensorineural hearing loss.

524. Advanced Problems in Perception and Action

An advanced course focusing on in-depth studies of several problems in perception and action. The first half of the course covers four problems in higher-level visual function—depth perception, object recognition, visual information processing in natural tasks, and the visual control of action, presented in seminar format. The second half is run as a grant-writing workshop in which students develop the major components of a research proposal (problem specification, background review, and research plan) in one of the four problem areas, through collaborative interactions in the class.

Advanced Seminars 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. Speech Recognition and Statistical Language Models
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. Sensory Motor Systems
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.

538. Computational Problems in Vision

An advanced seminar on the union of computational work and human vision. Topics vary but typical examples include levels of representation, parallel and serial processing, object recognition, distributed versus local representations, vision with a moving observer, and attention.
539. Computational Models of Behavior
This is an advanced seminar which reviews recent developments in computer vision, connectionism, and reinforcement learning and their relevance to human behavior.

Advanced Seminars 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.

544. 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.

545. 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.

Advanced Seminars 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.

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. Language Understanding

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.

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.

Other Advanced Seminars
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.

Other Courses
591. Readings at the Ph.D. Level
595. Research at the Ph.D. Level
598. Supervised Teaching
999. Doctoral Dissertation
Chemistry

Professors Boeckman (Chair), Dinnocenzo, Eisenberg, Farrar, Goodman, Jones, Kreilick, Krugh, Muenster, Rothberg, Schröder, Turner
Associate Professors Bren, Holland, Krauss
Assistant Professors Frontier, McCamant, Ng, Nilsson, Ovchinnikov, Stern
Professors (Research) Conwell, Farid
Joint Appointment: Professor Tang
Professors Emeriti Buff, Huizenga, Kampmeier, Kende, Saunders

The Department of Chemistry concentrates on programs leading to the Ph.D. degree. Training through coursework and research is available in the traditional areas of inorganic, organic, and physical chemistry, as well as in interdisciplinary areas such as nuclear, biological, materials, and theoretical chemistry.

The department facilities include research and teaching laboratories, mechanical and electrical shops, and a chemistry-biology-mathematics library. The department maintains modern research equipment, including extensive facilities in magnetic resonance, molecular beam, mass spectroscopy, electronic absorption and emission spectroscopy, X-ray diffraction analysis, and isotope chemistry. Researchers collaborate nationally and internationally, as well as with local industry such as Xerox Corporation and Eastman Kodak Company.

Applicants for admission to graduate work in chemistry should have at least one year each, including appropriate laboratory work, of general chemistry, inorganic chemistry, organic chemistry, physical chemistry, mathematics through differential and integral calculus and including an introduction to differential equations, and one year of physics. The Chemistry Graduate Studies Office maintains a booklet with the complete descriptions of departmental requirements for the Ph.D. The following description summarizes most, but not all, of those requirements.

Graduate students consult with their thesis advisors and the Chemistry Graduate Studies Committee to select the appropriate coursework. Courses are normally taken during the first two years of graduate study. All students take Seminar (511 or 513) and Colloquium (583). The course load after the first year normally does not exceed one course per semester in order to allow ample time for research.

All chemistry students must take a series of short examinations (cumulative examinations) given monthly; a certain number of these must be passed. Each graduate student must also pass during the second year an oral qualifying examination based on a report on the thesis research problem. Admission to doctoral candidacy occurs after satisfactory completion of all coursework, cumulative exams, and the oral exam.

In partial fulfillment of the requirements for an advanced degree in chemistry, all graduate students participate in the teaching program of the department. Previous teaching experience may be applied toward this requirement. All graduate students are required to complete a dissertation (CHM 999). The choice of the field and specific subject of this original research is left to the student and is limited only by the research interests of the faculty and the sizes of the various research groups. Students explore and discuss various research areas with the faculty early in the first semester of graduate study and select a research supervisor during that semester.

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)

411. Advanced Inorganic Chemistry
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)

417. 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. (Fall, 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, C\textsubscript{n}H\textsubscript{2n}, and related pi ligands. Oxidative addition, insertion, elimination reactions, and other fundamental reactions of organometallic compounds. (Fall, first half of semester)

422. 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, HMQC, HETCOR. Practical aspects of recording spectra are also included. (Spring, first half of semester)

423. Organometallic Chemistry—Survey
Prerequisite: CHM 421.
Credit—two hours
Mechanisms in organometallic reactions. Applications of organometallic compounds in homogeneous catalysis, polymerization, metathesis. (Fall, second half of semester)

424. Inorganic Spectroscopic Techniques
Prerequisite: CHM 422.
Credit—two hours
Molecular and electronic structure determination of inorganic compounds and metal complexes; spectroscopic and physical methods. (Spring, second half of semester)

426. 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. (Spring, 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. Organometallic Chemistry for Organic 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, second half of semester)

437. Bioorganic Chemistry  
Principles involved in 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. (Fall)

438. Advanced Synthetic Strategy  
Prerequisite: CHM 435.  
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, first half of semester)

450. Biochemistry  
An introduction to biochemistry. 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)

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 semiclassical techniques are covered. (Spring)

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

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, odd years)

460. Chemical Kinetics  
Prerequisite: CHM 451.  
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, even years)

461. Advanced Experimental and Computation Laboratory  
Prerequisites: CHM 251 and computer programming.  
A lecture and laboratory designed to prepare students for graduate research in experimental physical chemistry. Extensive computer programming is required to analyze and interpret experimental data. (Spring)

465/466. Nuclear Chemistry 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 or spring, every other 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.

511. Physical/Inorganic Chemistry Seminar  
Credit to be arranged  
Required of all graduate students in physical, inorganic, and biophysical chemistry during each semester they are registered.
513. Organic Chemistry Seminar
Credit to be arranged
Required of all graduate students in organic chemistry during each semester they are registered.

552. Topics in Chemical Physics
The special topics in quantum and statistical mechanics are selected from molecular collision theory, the theory of chemical kinetics, many-body techniques in quantum and statistical mechanics, the theory of liquids, gases, and solids, critical phenomena, and non-equilibrium problems.

561. Magnetic Resonance Spectroscopy
Theory and applications of nuclear magnetic resonance, electron spin resonance, and infrared and microwave spectroscopy.

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)

583. First-Year Seminar
No credit
Pedagogy in chemistry graduate school.

591. Reading Course at the Ph.D. Level
Credit to be arranged

592. Special Topics in Organic Chemistry
Credit—two hours
Advanced topics in organic chemistry.

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

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

999. Doctoral Dissertation
No credit
Full-time registration category for student who has completed 90 credit hours.

Clinical and Social Sciences in Psychology

Professors Davies, Deci, Elliot, Klorman, McAdam, Reis, Ryan, Smetana, Zuckerman (Chair)
Associate Professor Toth
Assistant Professors Bennetto, McDowell, Rogge
Joint Appointments: O'Connor, Palumbo, Williams, Willis, Wyman
Professors Emeriti Ilardi, Wheeler, Zax

The Department of Clinical and Social Sciences in Psychology offers programs of study leading to the Ph.D. 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 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 Ph.D. by passing the qualifying examination for the Ph.D. 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
Ph.D. 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; Web site: 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 Web site: www.psych.rochester.edu/graduate. However, if after reviewing this information you have specific questions about the program, please contact our Academic Coordinator (see Web site).

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**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>211</td>
<td>Introduction to Statistical Methods in Psychology</td>
</tr>
<tr>
<td>219W</td>
<td>Research Methods in Psychology</td>
</tr>
<tr>
<td>266</td>
<td>Research Laboratory in Social Psychology</td>
</tr>
<tr>
<td>373</td>
<td>Exploring Research in Social Psychology I</td>
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</tbody>
</table>

**Advanced Lecture Courses**

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<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>262</td>
<td>Human Motivation and Emotion</td>
</tr>
<tr>
<td>263</td>
<td>Relationship Process and Emotions</td>
</tr>
<tr>
<td>264</td>
<td>Industrial and Organizational Psychology</td>
</tr>
<tr>
<td>267</td>
<td>Psychology of Gender</td>
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<tr>
<td>276</td>
<td>Psychology of Parenting</td>
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</table>

**Seminar Courses**

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<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>301</td>
<td>Teaching Psychology</td>
</tr>
<tr>
<td>361</td>
<td>Social Psychology: Self-Concept</td>
</tr>
<tr>
<td>362W</td>
<td>Seminar in the Psychology of Gender</td>
</tr>
<tr>
<td>363</td>
<td>Attitudes: Structure, Function &amp; Change</td>
</tr>
<tr>
<td>364</td>
<td>Achievement and Motivation</td>
</tr>
<tr>
<td>366</td>
<td>Social Psychology and Control</td>
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<tr>
<td>367W</td>
<td>Gender &amp; Mental Health</td>
</tr>
<tr>
<td>368W</td>
<td>Seminar in Humanistic Psychology</td>
</tr>
<tr>
<td>371</td>
<td>Seminar in Social &amp; Personality Development</td>
</tr>
<tr>
<td>376</td>
<td>Seminar in Self-Determination</td>
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<tr>
<td>374</td>
<td>Exploring Research in Social Psychology II</td>
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<tr>
<td>377</td>
<td>Exploring Research in Family Psychology I</td>
</tr>
<tr>
<td>378</td>
<td>Exploring Research in Family Psychology II</td>
</tr>
<tr>
<td>278</td>
<td>Adolescent Development</td>
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<tr>
<td>280</td>
<td>Clinical Psychology</td>
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<tr>
<td>282</td>
<td>Abnormal Psychology</td>
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<tr>
<td>283</td>
<td>Behavioral Medicine</td>
</tr>
<tr>
<td>289</td>
<td>Developmental Childhood Psychopathology</td>
</tr>
<tr>
<td>380</td>
<td>Theoretical Perspectives on Psychotherapy</td>
</tr>
<tr>
<td>381</td>
<td>Psychology of Developmental Disabilities</td>
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<td>383</td>
<td>Moral Development</td>
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<tr>
<td>384</td>
<td>Practicum in Developmental Disabilities I</td>
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<td>Practicum in Developmental Disabilities II</td>
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<td>386</td>
<td>Advanced Emotional Development</td>
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<tr>
<td>388</td>
<td>Research Practicum in Developmental Psychopathology I</td>
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<tr>
<td>389</td>
<td>Research Practicum in Developmental Psychopathology II</td>
</tr>
<tr>
<td>396</td>
<td>Seminar in Special Topics</td>
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</table>
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.

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.

554. Social Psychology of Sex Roles

An introduction to sex roles, sex-role stereotypes, and their implications for social behavior and mental health.

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.

565. Fatherhood
This seminar examines the role of the father in child development. Included are the ways in which father absence and father presence impact children. We examine the personal, social, and institutional problems associated with promoting father involvement. Other topics include fathering in nontraditional families, methodological considerations of studying fathers, and historical and policy change related to fatherhood.

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, psychophysiology, 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)

581. Advanced Clinical Seminar

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

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 Ph.D. 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 Ph.D. Level
Credit to be arranged

597. Pedagogy of Psychology
Curriculum and course design and delivery in psychology are considered at general and specific levels.

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.

Cognitive Science
Associate Professors Bavelier, McDonough, Nelson, Pouget, Runner, Supalla, Weliky
Assistant Professor Gildea

The University of Rochester does not offer a degree in cognitive science. Instead the Cognitive Science Program is an interdepartmental program taught by faculty who collaborate on research and teaching. The faculty come from the Departments of Brain and Cognitive Sciences, Computer Science, Linguistics, and Philosophy, and from the Neuroscience Program. Areas of special research are language, cognition, representation and reasoning, vision and action, cognitive modeling, and neuroscience. Students pursue Ph.D. degrees through the University’s interdisciplinary Ph.D. program. Contact the Department of Brain and Cognitive Sciences for more information.

THE GRADUATE PROGRAM IN COGNITIVE SCIENCE
The interdisciplinary Ph.D. program operates in conjunction with the participating departments. Students in this program typically have a home or “major” department and also a “minor” department. Students must fulfill two-thirds of their home department’s requirements and one-third of the requirements of their minor department. In addition, students must write interdisciplinary dissertations, and have faculty members from both their home and minor departments serve on their dissertation committees.

To become a cognitive science student, one must first be accepted into the graduate program of the participating department that will serve as the student’s home department. Once accepted for admission to the home department, the student may then design a program in coordination with his or her advisory committee and department. Some areas of research have a well-defined structure and a standard set of guidelines to work from when designing a program. Other programs of study may be designed specifically to fit the student’s individual research interests. The procedures are specifically designed to provide maximum flexibility for the student whose research interests cross traditional department boundaries.
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 Ph.D. 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. Ph.D. students receive financial support as research assistants (or are fellowship recipients). They are required to serve as teaching assistants for two to three semesters.

Ph.D. 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 Ph.D. 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 M.S. degree (Plan B) on either a full-time or part-time basis. A "professional master's" is typically an M.S. 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 in the M.S. programs.

M.S. students must pass a comprehensive examination (or essay), typically in the last semester before graduation.

The only required course for Ph.D. students is CSC 400. For M.S. 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.

417. Uncertain Inference

The problem of quantifying the uncertainty that characterizes most inference outside of logic and mathematics. This is important to both philosophy and artificial intelligence. The various probabilistic and nonprobabilistic measures that have been proposed are explored and evaluated.

419. Deviant Logic

The study of “alternative” logics: logics in which more than two truth values are possible, logics in which not every statement has a truth value, logics that are designed to accommodate vagueness, logics that allow inconsistencies. Some of these alternatives have been suggested on philosophical grounds, others on pragmatic grounds. Acquaintance with first-order logic is assumed.

443. Introduction to Computational Neuroscience

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.

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. Speech Recognition and Statistical Language Models

Statistical natural language processing and automatic speech recognition techniques. 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. Sensory Motor Systems

Introduction to computer vision, including model-based vision, projective invariance, Hough transforms, pattern recognition and neural nets, color theory, texture, and optic flow.

455. Advanced Programming Systems

Principal topics in understanding and transforming programs at the assembly, function, and program levels. Specific techniques for imperative languages include data flow, dependence, and inter-procedural analyses; resource allocation; and program transformation for locality and parallelism. The course also touches on theoretical issues in program semantics for higher-order languages. Course projects include a program analyzer and optimizer for a subset of the C programming language.

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


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, multi-processor architectures, parallel program optimization, and parallelizing compilers.

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. Ph.D. Readings in Computer Science
Credit to be arranged
Reading course at the Ph.D. level.

594. Ph.D. Research Internship in Computer Science
Prerequisite: permission of the department.
Credit—one hour
Ph.D.-level research internship with sponsoring employers, usually taken during the summer term and lasting three–four months.

595. Ph.D. Research in Computer Science
Credit to be arranged
Individual research at the Ph.D. level.

Earth and Environmental Sciences

Professors Basu, Ebinger, Fehn, Mitra, Poreda, Tarduno (Chair)
Associate Professor Garzione
Professors Emeriti Lundgren, Sutton

The department offers programs of study leading to the degrees M.S. and Ph.D. 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 and geophysics, solid earth geochemistry, noble gas geochemistry, cosmogenic isotope geochemistry, light stable isotope geochemistry,
environmental geochemistry and biogeochemistry, sedimentary geology, stratigraphy, structural
geology, and tectonics. Information on this research can be found at the department's Web site:
www.earth.rochester.edu.

Graduate research is facilitated by the department’s Center for Analytical Geosciences, which
includes a number of state-of-the-art laboratories that complement active field-based research pro-
gram. Ongoing projects supported by the center focus on topics as diverse as the motion of tectonic
plates, the origin of mantle “plumes,” groundwater chemistry, and the effect of extraterrestrial im-

cacts on the history of life.

The center’s four mass spectrometers support research in geochemistry. These instruments in-
clude a Thermo Electron IRMS, a VG Plasma54 multicollector ICP-MS, a VG PQ II+ quadrupole
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 prepara-
tion is carried out in the department’s cleanlabs, which feature Class 100 air supplies, laminar flow
workspaces, and metal-free environments.

Research in paleomagnetism and geophysics is carried out in the paleomagnetic laboratory which
features a 2G 755R DC SQUID Superconducting Rock Magnetometer, a Princeton Measurements
2900 Alternating Gradient Force Magnetometer, and a Geofyzika JR-5A high-speed automatic spin-
ner magnetometer. Data are analyzed using Sun Microsystems UltraSparc workstations.

Equipment in the structural geology laboratory includes Olympus and Nikon research micro-
scopes (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 soft-
ware.

Other analytical equipment includes an automated powder X-ray diffractometer, a UV-VIS spec-
trophotometer, and an ion chromatograph. A Frantz isodynamic separator and a microwave digestion
system are also available, along with a variety of specialized equipment for fossil preparation and
morphological study. Also available are rock cutting and thin-sectioning equipment and a technician
to prepare petrographic thin-sections.

Graduate students are generally 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, special consideration is given to students with strong backgrounds in
particular areas of science (esp. chemistry, biology, physics, engineering, and materials science) even
if they have only a modest background in geoscience. Financial aid is available in the form of teach-
ing and research assistantships and fellowships. Applications from qualified women and minorities
are strongly encouraged.

The department offers a five-year B.S./M.S. program for highly qualified University of Rochester
undergraduates. Students should apply to the program during the fall of their junior year. M.S. stu-
dents are expected to spend most of their time 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 Grad-
uate Studies Coordinator. To ensure that candidates for the M.S. and Ph.D. 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 towards understanding the processes which shape them and the environments in which they form.

204. Mineralogy
Introduction to crystallography, crystal structure, crystal chemistry and classification, and origin of important rock-forming minerals. (Spring)

205/405. Geophysics
Composition of the earth; radioactivity and age of the earth; gravity field and rotation; earthquakes and propagation of seismic waves; magnetic field; paleomagnetism; heat generation and heat flow; plate tectonics and convection in the earth. (Alternate semesters)

206/406. Petrology-Geochemistry
Distribution, description, classification, and origin of igneous and metamorphic rocks in the light of theoretical-experimental multi-component 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. Invertebrate Paleontology
Introduction to the subject by examination of the principles of paleontology and by a review of the invertebrate organisms of the past. (Fall)

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.

214. Environmental Geology
Examines the geological processes that shape our surface environment. Topics focus on the interactions between natural processes (e.g., volcanic eruptions; earthquakes; glaciers; fluvial, coastal, and groundwater systems) and the changing human environment. (Spring)

215. Environmental Geophysics
Physical processes at the surface of the earth. Sources of energy: solar energy; radioactive heat generation; heat conduction and convection. Dynamics of the crust; earthquakes and propagation of seismic waves; plate tectonics. Movement of fluids in the oceans, rivers, and crust; physics of atmospheric movements. Influence of human activities on physical processes at the surface of the earth. (Fall)

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.

219. Energy and Mineral Resources
Energy sources presently in use, their availability, and their environmental and economic consequences. Alternative energy sources, their potentials and problems. The distribution and formation of mineral resources. Reserves, rates of production, and consumption of important minerals. (Spring)
285. Structure and Tectonics of Mountain Belts  
Prerequisite: EES 208 or equivalent.

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)

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)

319W. Energy Decisions  
Investigation of the decision-making processes leading to the use of specific energy sources in developed countries, with special attention given to USA and Germany. Review of energy sources in use today (hydrocarbons; nuclear) and potential alternatives (wind; solar); comparison of electoral systems, history of environmental movements, and decision processes in the USA and Germany. Seminar course; evaluation based on oral presentations and papers. Fulfills Department of Earth and Enviromental Sciences writing requirement.

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

210/410. Analytical Methods in Geochemistry  
A laboratory-based, hands-on introduction to selected analytical methods commonly employed in the study of geological and environmental problems. Standard methods of sample preparation, elemental separation, and mass spectrometric analysis are used to determine elemental concentrations and isotopic compositions. Students are required to complete laboratory exercises as well as a term project to be agreed upon with the instructor.

218/418. The Chemistry of Global Change  
A quantitative survey of the processes controlling environmental conditions at the earth's surface today, how they have changed with time, and how they are expected to change in the future. The course emphasizes the chemical composition of the atmosphere and oceans, and the chemical, biological, and geological processes which affect this composition. Specific topics include greenhouse gases and global warming; photochemistry and stratospheric ozone; geochemical cycles and feedbacks; the effects of human activities; and the methods used to study the chemical evolution of the atmosphere and oceans through time.

240/440. Optical Mineralogy  
Prerequisite: EES 204 or permission of instructor.

Principles of optical crystallography and their application in the identification of rock-forming materials, mostly the silicates, with the polarizing microscope.

241/441. Igneous-Metamorphic Petrology  
Prerequisite: EES 204.

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)

442. Sedimentary Petrology  
Prerequisite: EES 240.

Petrographic analysis of clastic and carbonate rocks. Emphasis is on tectonic influences on sandstone composition and diageneis.
445. The Solid Earth
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.

248/448. High Temperature Geochemistry
Prerequisites: CHM 103 or 105 and MTH 161.
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)

252/452. Marine Geology
Prerequisite: EES 101.
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)

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.

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)

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.

264/464. Paleoenvironmental Reconstructions Using Light-Stable Isotopes
This class focuses on techniques used in environmental reconstructions to address questions related to paleoclimate, paleotemperature, paleovegetation, and paleoelevation. 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.

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

466. Seminar in Geochemistry
A research seminar covering a current topic or topics in geochemistry, at the graduate level. (Spring)

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.
268/468. Chemical and Isotopic Hydrology
Prerequisites: EES 230 and EES 216.

The application of physical, chemical, and isotopic data to the study of groundwater systems. Case studies are used to demonstrate the applications. (Spring)

269/469. Stable Isotopes in Geochemistry

Application of stable isotope techniques to problems in metamorphic and igneous petrology, hydrothermal alteration, paleoceanography, paleoclimatology. (Spring)

274/474. Seminar in Paleoceanography
Prerequisite: permission of instructor.
Credit—two hours

Topics of discussion include the history of deep water formation and surface circulation, geochronology, stratigraphy, and ocean chemistry, and the results from deep-sea drilling in general.

478. Seminar in Depositional Environments
Prerequisite: EES 207 or 203.
Credit—two hours

A survey of major paralic and marine sedimentary environments, their processes, and characteristic facies sequences. Case studies of ancient facies are discussed, together with modern analogs. Sequence stratigraphy devoted to study of the concepts and applications of sequence stratigraphy in outcrops, wells, and seismic sections. (Fall)

479. Evolutionary Paleontology
Prerequisite: EES 207.

Evolutionary paleontology assumes familiarity with the concepts presented in EES 207 and takes a more in-depth look at topics such as evolutionary ecology (e.g., development of diversity, mass extinction events), evolutionary change at the organismic level (e.g., morphometric studies, cladistics and the fossil records, paleobiogeography), and also examines the interdependence of geochronological and "molecular clock" studies. The purview of the course includes microbial, invertebrate, and vertebrate groups.

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
Prerequisites: EES 206 and 208.

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

283/483. Sedimentary Basin Analysis

By determining how sedimentary basins develop and fill, we better understand the tectonic and eustatic controls on subsidence and surficial processes. Basin classification schemes, flexural and thermal subsidence, isostasy, sequence stratigraphy, and techniques used to characterize sedimentary basin evolution are discussed.

484. Stress and Strain in Rocks


286/486. Seminar in Sedimentology and Tectonics

Interpreting the lithofacies and chemistry of sedimentary rocks to understand paleoenvironment; impact of tectonics on climate. Topics vary. Readings, presentations, and discussions of classic and current literature.

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)

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. Ph.D. Readings in Geology

595. Ph.D. Research in Geology
Credit to be arranged
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 additional years of on-campus dissertation research. This Ph.D. 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.

During the first year, students typically take five core courses (ECO 471, 472, 475, 476, 481) as well as the econometrics sequence (ECO 483, 484, 485). These requirements provide the foundation of modern economic analysis upon which the whole program builds.

Each student subsequently develops two fields of specialization. The available fields are capital theory, econometrics, economic history, game theory, general equilibrium theory, industrial organization, international economics, labor economics, macroeconomics, public finance, and political economy. (For more information about political economy, see W. Allen Wallis Institute of Political Economy.) The student's preparation is evaluated by a written qualifying examination in each of the fields 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 Ph.D. 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 Web site 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.

517. Advanced Econometrics
(Same as 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
(Same as 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. Topics in Contract 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. Dynamic Competitive Analysis
The focus of this course is on studying macroeconomic models with many types of households and firms. Models of capital, labor, financial, and marriage markets are presented. Issues such as adoption of new technologies, the determination of asset prices, marriage and divorce, and unemployment are studied. The development of the mathematical and computational skills required to do state-of-the-art-research in macroeconomics is stressed.

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 Ph.D. Level

Credit to be arranged

595. Research at the Ph.D. Level

Credit to be arranged

English

Professors Bleich, Eaves, Gross, Hahn, London, Longenbach, Michael, Peck, Scott, Shuffelton (Chair)
Associate Professors Grella, Higley, Jordan, Kegl, Tucker
Assistant Professors Anastasopoulos, Guenther, Li, Mannheimer, Niu
Adjunct Appointments: Professor Lupack
Senior Lecturers Maister, Rossen-Knill, Smith
Professors Emeriti Gavin, Gollin, Hazlett, Hoy, B. Johnson, J. W. Johnson, Ramsey

The Department of English offers programs of study leading to the degrees Doctor of Philosophy or Master of Arts. Candidates for the M.A. degree may pursue their work either as full-time or part-time students. Full-time candidates for the M.A. can ordinarily complete the 30 hours of required coursework and other prerequisites for the degree in one calendar year. M.A. candidates are required either to write a master's essay under the direction of a faculty supervisor, or to take a written comprehensive exam.
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 M.A. Normally three years of coursework (directed readings) are required of doctoral candidates who enter with the B.A. Usually two years of formal study are required of those entering the doctoral program with the M.A. Candidates 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, who is a member of the English faculty. Ph.D. students are not ordinarily expected to teach in their first two semesters of study, but are expected to devote full time to their coursework. Before the end of their second year, Ph.D. students select a faculty committee with whom they work to define and prepare areas of specialization for their qualifying exams. Students generally take their qualifying exams in the spring of their third year. After completing their exams, students must file a prospectus for their doctoral dissertation.

There is no foreign language requirement for the M.A. degree, but Ph.D. candidates 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 language requirement should be satisfied by the end of the candidates’ third year of study.

Graduate Seminars

500. Graduate Colloquium
501. Theory and Practice of Textual Criticism
504. Old English Literature
   Prerequisite: ENG 201 or equivalent.
506. Chaucer
507. Middle English Literature
508. Medieval Literary Modes
509. Shakespeare
512. Studies in Sixteenth- and Seventeenth-Century Literature
514. Studies in Renaissance Culture
516. Elizabethan and Jacobean Drama
524. Restoration and Eighteenth-Century Literature
526. Studies in Eighteenth-Century Culture
529. English Romanticism
530. Studies in Victorian Literature and Culture
533. Victorian Poetry
538. Studies in Early American Literature
539. Studies in Nineteenth-Century American Literature I
540. Studies in Nineteenth-Century American Literature II
542. Twentieth-Century American Literature
543. Studies in American Culture
545. Studies in African-American Literature and Culture
548. Studies in the Novel
549. Twentieth-Century British Literature
550. Modern Poetry
551. Criticism
552. Problems in Contemporary Theory
553. Issues in Feminism
554. Cultural Studies
555. Issues in Film History and Theory
557. Special Literary Problems
558. Video History and Theory
560. Studies in Rhetoric and Literacy
Research, Supervised Teaching, and Reading Courses

571. Ph.D. Supervised Teaching  
Credit—five hours  
Students for the doctorate are required to teach two sections of College Writing as part of their professional training. Prior to the first semester of such teaching, students enroll in ENG 571, which studies practice, theory, and philosophy of teaching. In addition students enroll in a two-credit seminar practicum while teaching.

572. Practicum in Teaching  
Credit—two hours

591. Reading Course at the Ph.D. Level  
Credit to be arranged

595. Research at the Ph.D. 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)  
English sounds, inflections, syntax, and vocabulary, emphasizing the structure of present-day English.

401. Old English Literature  
Literature written in England before the Norman Conquest. Latin works are read in translation; vernacular works, in the original.

402. Middle English Literature  
Poetry, prose, and drama of the thirteenth, fourteenth, and fifteenth centuries, exclusive of Chaucer. Readings in Middle English.

403. Medieval Drama  
English drama from its beginnings until 1580.

404. Chaucer  
The principal works of Chaucer, in their historical and intellectual context. Readings in Middle English.

406. Studies in Medieval Literature

407. English Renaissance Literature  
From More to Spenser, with some attention to the continental background.

408. Renaissance Drama  
English Renaissance drama through 1642, exclusive of Shakespeare.

409. Studies in Shakespeare

410. Shakespeare

411. Milton  
The works of Milton in their historical and intellectual context.

413. Studies in Renaissance Literature

414. Eighteenth-Century Literature  
(1660–1780)  
A survey of the major works of the period.

415. Early British Novel  
The novel from the beginnings to the early nineteenth century, emphasizing such novelists as Defoe, Fielding, Richardson, and Austen.

417. Studies in Eighteenth-Century Literature

418. Early American Literature  
From 1630 to 1830, including Bradford, Taylor, Mather, Edwards, Franklin, Freneau, Cooper, Bryant, and others.

420. Romantic Literature  
Major writers, other than novelists, of the early nineteenth century, with particular emphasis on poets from Blake through Keats.

421. Victorian Literature  
The major intellectual, cultural, and artistic developments of the Victorian period, in prose, drama, verse, and related arts.

422. Nineteenth-Century British Novel  
Emphasizing such novelists as Dickens, Thackeray, Eliot, and Hardy.

423. Studies in Nineteenth-Century Literature

425. American Romantics  
From 1830 to 1865, including Emerson and the Transcendental movement, abolitionist writing and slave narrative, representative fiction, and poetry by Poe, Whitman, Melville, Stowe, and others.

426. American Realists  
From 1866 to 1912, including poetry by Dickinson and Frost; realist and naturalist fiction by Twain, Wharton, James, Dreiser; representative nonfiction and philosophy.
427. American Moderns
From 1913 to 1941, including Eliot, Stevens, Faulkner, Hemingway, Fitzgerald, O'Neill, W. C. Williams, and others.

428. African-American Literature
Major autobiographies and novels by African-American writers such as Frederick Douglass, Richard Wright, Maya Angelou, and Toni Morrison.

430. Studies in American Literature
431. The Twentieth-Century British Novel
The novel from 1900 to the present.

432. Modern Literature
433. Modern Poetry

434. Modern Fiction
Great modern drama from Ibsen to Ionesco as a reflector of the main currents in modern thought and feeling.

436. Contemporary Fiction
A survey of fiction from World War II to the present.

437. Contemporary Poetry
Poetry in English from around 1945 to the present, emphasizing latter-day transformations and rejections of the visions and style of High Modernism.

438. Studies in Modern and Contemporary Literature
440. Literary Criticism and Theory
An introduction to the history, theory, and especially the practice of criticism.

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. Literature and Ethnicity
451. Studies in Popular Literature

452. Theater in England
453. Literature of the Bible
454. Arthurian Literature
455. Silent Cinema
456. Sound Cinema
458. Film Analysis
459. Popular Film Genres
An intensive study of selected types of popular films in their larger cultural context.

460. Film History
This course may approach a national cinema, a director, a movement, or a genre with an emphasis on period or historical context.

461. Film Theory
An introduction to the history, the theory, and especially the practice of film criticism.

462. Studies in a National Cinema
Films from a particular (foreign) national cinema—Japanese, German, French, Italian, and others from various periods.

463. Media Studies
Addresses the history and theory of a range of communications media and visual technologies in science, industry, and popular culture.

464. Studies in a Director
A course in the works and career of an outstanding and identifiable film director: Hitchcock, Warhol, Huston, Bunuel, Renoir, etc.

465. Issues in Film
The course takes up particular concepts, ideas, and ideology in film often spanning periods, nations, and genres.

466. Issues in Film Theory
467. Topics in Media Studies
468. Museum Studies
475. Creative Writing: Poetry
476. Creative Writing: Fiction
480. Hypertext Writing
483. Media ABC
484. Orality, Language, and Literacy

491. Reading Course at the Master's Level
Credit to be arranged
**History**

Professors Applegate, Brown, Hauser, Inikori, Kaeuper, Mandala, Outram, Rubin, Weaver (Chair), Westbrook
Associate Professors Borus, Hudson, Lenoe, Wolcott
Assistant Professors Jarvis
Joint Appointments: Professors Engerman, Segal, Walsh; Associate Professors Gamm, Gordon, Federsen
Professors Emeriti Berman, McGrath, Miller, Moore, Waters, Young, Zagorin

The Department of History offers programs of study leading to the degrees Doctor of Philosophy and Master of Arts. The program leading to the doctorate places special emphasis upon the training of effective teachers and productive scholars of American, European, and global history. A detailed description of the graduate programs for the doctorate may be obtained upon request. Please also see the department’s Web site: [www.rochester.edu/College/HIS](http://www.rochester.edu/College/HIS).

A reading knowledge of two foreign languages, usually French and German, is required of all candidates for the Ph.D. in European and global history; there is no standard language requirement for candidates for the Ph.D. in American history.

Ph.D. candidates who receive fellowships awarded by the department normally serve as teaching assistants during their second year of residence. After serving as teaching assistants, doctoral students may elect to participate in the College Writing Program during their third and fourth years. In this program, students design and run their own courses for a supplementary stipend and become eligible for competition to teach such courses in the fifth and sixth years for additional compensation. The duties associated with these teaching assistantships are to be considered an integral part of the students’ preparation for the Ph.D. degree. All teaching assistants will be evaluated on their performance by the faculty. Teaching assistants will register for HIS 593.

Ph.D. candidates in all fields are required to complete 11 courses. M.A. candidates are required to complete at least four graduate-level seminar courses.

Credit for the following courses is five hours, except HIS 491, 495, 591, 592, 593, and 595.

402. **Power of Print: Readers and Reading in American History**
   This course examines the history of books, readers, and literacy with emphasis on 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). The course considers such topics as the relationships between gender and reading; the connections between reading and citizenship; the impact of technological change on the book; the social uses of various kinds of reading; and the nature and development of literacy.

403. **Maritime History of the Atlantic World**
   This course breaks with past tradition in the study of European expansion by shifting the focus of inquiry to the Atlantic Ocean itself as the geographic center of an expanding European world.

404. **The Beats and Beyond: 1950s America**
   This course explores the contradictions of the 1950s through an examination of social, political, and cultural history.

405. **American Health Policy and Politics**
   The political and historical study of principal events in the development of American health policy from 1932 to the present.

406. **European Cultural History**
   The use of novels, plays, paintings, poetry, and other artistic forms of approaching the study of the modern European past.

407. **European Thought, 1750–1870**
   Survey of intellectual trends and thinkers in Europe from the eighteenth-century Enlightenment through its late nineteenth-century challengers; readings from Voltaire, Lessing, Rousseau, Kant, Schiller, Hegel, Schopenhauer, Carlyle, Mill, Comte, Marx, and Nietzsche.

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

410. **Progressive America**
   Study of the cultural, intellectual, and political life of the United States, 1900 to 1920.
411. History of American Popular Culture
This colloquium explores the historical meanings of the sounds, images, and words that a majority of Americans have embraced in the twentieth century. It concentrates on the debates over whether commercially oriented expression enhanced or detracted from American democracy and on the ways in which popular expression made and was made by historical developments.

412. Cultural History and Its Critics
Critical study of trends and problems in cultural history, focusing on central tensions within the field and external challenges from anthropology and literary theory.

413. American Foreign Policy
This seminar explores significant political, economic, and cultural themes in the United States’ relationship with other countries from the eighteenth through the twentieth centuries, with the emphasis on the latter.

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.

415. Topics in the History of Women
The history of women in the United States and Europe in the eighteenth, nineteenth, and twentieth centuries.

416. Women in Western Culture: Europe and America
This seminar deals with the modern history of women in Europe and America. Emphasis is placed on the creation of gender ideologies; on how women actually lived, the ways in which religion, class, and race shaped the experiences of women individually and collectively, and women’s strategies of resistance and accommodation to patriarchy over the last three centuries, including the emergence of modern feminism(s).

418. Nationalism and Ethnic Conflict in Europe
The history of the concepts and actuality of national identity, ethnicity, and nationalism in modern Europe with attention to the challenges to national integration posed by migration, political upheaval, and ethnic conflict.

419. A Historic Perspective on the Economic, Institutional, Legal, and Geopolitical Aspects of Globalization
The object of this seminar is to explore the legal processes of adjudication in international affairs, the nature and effect of contending economic theories, and the organizations and mechanisms through which the system operates, all in the overall context of the history of world trade. The seminar shall also attempt to develop imaginative new approaches for dealing with the problems arising from national assertions of sovereignty and regulatory control, world labor arbitrage, polarizing distribution patterns among the rich and poor of the world, and worldwide production overcapacity and terrorism.

420. The German Problem
How historians (from Treitschke to the Historikerstreit) have analyzed Germany’s unique place in the West; political contexts of historical debates on Germany’s past.

424. Culture of Cities in Modern Europe
In seminar format, this course explores the development and character of both large and small cities in modern Europe with particular attention to central Europe. The course considers the transformation of urban space in relation to nation-building, industrialization, and commercialization, and the development of mass or class cultures.

425. The Arts of Chivalry
(Same as AH 448)
This course deals with aspects of visual culture in Europe during the thirteenth and fourteenth centuries, principally in England and France.

432. Topics in Early American History
This seminar introduces students to recent scholarship in the study of early America. Topics and approaches include slavery and the formation of African-American culture, Revolutionary resistance, Euro-Indian encounters, religion and witchcraft, microhistory, gender roles, warfare, and environmental history.

433. U.S. Colloquium I
This seminar surveys the historiographic development of colonial and antebellum America, stressing the ways in which scholarly interpretation of topics and events in these periods have changed over the last century.
434. U.S. Colloquium II
Continuation of HIS 433. An introduction to major historiographical issues of the postbellum United States. Texts are those with which all historians of the United States need to be familiar to understand the transformations in social, cultural, economic, and political life that characterize modern America.

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

436. Plantation Societies in the Sixteenth and Seventeenth Centuries
Investigates European and African origins and structure of plantation society in the New World.

437. Plantation Societies in America in the Eighteenth and Nineteenth Centuries
Examines the establishment, expansion, and modernization of plantation society in the United States, Latin America, and the Caribbean.

438. Immigration and Ethnicity in American History
This seminar analyzes the historiography of immigration and ethnicity in American history by reading some of the classic works in the field.

439. America at War: The Civil War and Reconstruction
Examines the changing ideas about nation, place, race, and gender, and asks: did the North and South differ fundamentally in their interpretations of democracy, progress, individualism, egalitarianism, and freedom?

440. The Black Family in Slavery and Freedom
Examines the public and social policy implications of the historiography of the black family in slavery and freedom.

441. Topics in the History of Ethnicity in the United States

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. North Africa and the Middle East in the Age of Imperialism
The social, political, and economic consequences of the region's incorporation into the capitalist world economy from the early nineteenth century to the present.

450. Topics in Medieval History
Selected problems in the political, social, and intellectual history of the Middle Ages.

451. Approaches to the History of Women
This research seminar examines major works in European and American women's history, gender studies, and feminist historiography as a foundation for students' original research in these fields.

453. Topics in the History of Medicine
Intensive readings, discussion, and research at the graduate level in topics in the history of medicine and public health.

454. Topics in the History of Science
Intensive readings, discussion, and research at the graduate level in topics in the history of science.

455. Men, Women, and War in the Twentieth Century
This research seminar focuses on the changing lives of European men and women before, during, and after the First and Second World Wars.

456. The Atlantic Slave Trade, 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.

457. Evolution of the Current World Economic Order From 1500
This research seminar traces the historical origins of the two defining elements of the current global economic system, integration, and hierarchy. It examines specifically the historical forces which produced the unequal international division of labor between industrial and nonindustrial nations, starting with the British Industrial Revolution which occurred within the Atlantic world economy.
459. Introduction to the Global World: Current Problems and Historical Roots
This course introduces historical study of the factors which have gone to make today's global world. Topics covered include the migrations of people, microbes, plants, animals, and ideas; technology transfer between different cultures; mapmaking and cartography; issues of global imaging, modeling; global governance issues; debates on liberalism and multiculturalism; culture contact; the growth of academic disciplines, such as geography and anthropology, which also help to shape a unified world; concepts of cultural imperialism.

460. War, Money, and Ordinary People: Topics in European History, 1648–1789
This course explores important topics in early modern history (about 1500 to about 1750), such as the lives of ordinary people, famine and poverty, warfare, court societies, formation of nation states, the Enlightenment, and the growth of a public for art, literature, and politics.

462. Seminar in Western Monasticism
This seminar explores the variety of forms of monasticism in Western Europe during the Middle Ages.

463. Topics in Modern French History
Research seminar on selected topics in modern French history between 1815 and 1944.

467. Topics in Modern Germany History
This course examines important problems in the social and political history of modern Germany and significant theoretical and methodological approaches to them.

475. Leisure and Recreation
This research seminar examines American attitudes toward leisure and the role of popular culture in American history.

476. Topics in American Social History: Women and Gender
This research seminar discusses gender and language, community history, considerations of race and class when writing about women; and the history of gay/lesbian communities.

477. Topics in Early American History
This seminar surveys the historiographic development of colonial and antebellum America, stressing the ways in which scholarly interpretation of topics and events in these periods have changed over the last century.

479. Oral History: Theory and Methods
Examines the major approaches to the production of oral history projects, from their conception to final completion.

480. Topics in African-American History
A research seminar on selected topics in twentieth century African-American political and social history. The impact of migration, urbanization, ideology, divergent African-American spokespeople, racial uplift and racial advancement organizations, and progress on the creation of a national African-American community are some of the topics discussed.

481. Topics in Nineteenth-Century American Cultural History
Research seminar on selected topics in nineteenth-century American cultural history, emphasizing recent scholarship.

482. Topics in Twentieth-Century American Cultural History
Research seminar on selected topics in modern American cultural history, emphasizing recent scholarship.

483. Cultures of Print
This research seminar explores the politics and culture of authorship, reading, publishing, identity, and access to knowledge, emphasizing the American past.

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.

485. Guns, War, and Revolution in Southern Africa
Explores the conditions that created revolutionary movements in Southern Africa, the conduct of warfare, and how the conflicts reshaped the region's position in the global economy after the Cold War.

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).
The Department of Linguistics offers an M.A. in linguistics, and participates in programs offering interdisciplinary joint Ph.D. 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.

**488. The Chinese Cultural Revolution in History and Memory**
An examination of the cultural project of commemorating the chaotic Cultural Revolution in the post-Mao period (1976–present).

**491. Reading Course at the Master's Level**
Credit to be arranged
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

**500. Problems in Historical Analysis**
This course addresses questions of interest to beginning graduate students in history: the history of the historical profession, styles of historical writing, relations between history and literature, ethno-history, and the functions of history as criticism and as social memory.

**501. Problems in Global History**
Looks at the ways in which the world has become a set of interlocking systems.

**502. Problems in Historical Analysis**
Credit to be arranged

**590. Supervised Teaching in History**
Credit—three hours
Individual instruction in the teaching of history under the supervision of a faculty member. For first-year Ph.D. students.

**591. Directed Readings Course at the Ph.D. Level**
Credit to be arranged
Individual, specialized reading courses; topics, relevant to student's program, chosen in consultation with faculty member.

**592. Independent Readings Course at the Ph.D. Level**
Credit to be arranged
Individual readings course pursued independently in consultation with faculty member; topics relevant to student's program.

**593. Assisting in History**
Credit—three hours
Experience, under faculty supervision, in conducting discussion sections and examinations in undergraduate history courses.

**595. Research at the Ph.D. Level**
Credit to be arranged

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**Linguistics**

Professor Carlson
Associate Professors McDonough (Chair), Runner
Assistant Professor Gunlogson
Joint Appointments: Professors Allen, Tanenhaus; Associate Professor Supalla
Instructors *Paauw, *Webb
Professors Emeriti Carlton, Moutsos, Sapon

The Department of Linguistics offers an M.A. in linguistics, and participates in programs offering interdisciplinary joint Ph.D. 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 M.A. in Linguistics**
The Department of Linguistics at the University of Rochester offers graduate training in linguistics leading to the Master of Arts (M.A.) degree. The emphasis for the master’s program is to prepare students for further work at the Ph.D. 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.

* Primary appointment in another department
3. Exploration of the relationship between theoretical linguistics and other fields of cognitive science.

4. Preparation for the teaching profession.

It is also possible to integrate the study of linguistics into Ph.D. 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.

Candidates should submit completed applications and 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
   Methods by which the history of languages and language families are studied.

406. Field Methods
   The methods by which the structures of previously unstudied languages are uncovered.

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. Attention is given to articulatory phonetics, with some discussion of acoustic phonetics; 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.

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
   Examines the grammatical structure of words and sentences from the standpoint of modern linguistic theory. The course develops the basic techniques and concepts of morphological and 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. Lexical Semantics
   General introduction to the study of word meaning. It covers various theories of the structure of words, the differences and similarities in lexical semantic structure between different languages, and the relationship of word meaning to sentence meaning and syntax.

426. Morphology
   Morphological segmentation and classification; derivational and inflectional processes; phrase structure and constituent analysis; relationship of structures and transformations.

427. Topics in Phonetics and Phonology
   Provides a clear understanding of the issues around the linguistic function of pitch and meter, solid basis for evaluating current claims about their cognitive representation, and the role of empirical data in the resolution of surrounding issues. We explore the theoretical and empirical foundations of the autosegmental and metrical approaches to the functions of pitch and meter in human language. Discussion topics include stress and metrical theory, the typology and phonological organization of pitch in its various grammatical aspects (tone, accent, stress, and intonation). We are concerned with the resource of instrumental phonetics as a source of data for phonological theories about pitch and
meter and the development of quantitatively explicit models of FO that the availability of fast computers and speech analysis technology has enabled. Participants are familiarized with the software tools used in the analysis of speech and pitch, including the ToBI transcription system.

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.

449. Studies in Language Structure
Investigations into the linguistic structure of a selected language or family of languages.

460. Syntactic Theory
This course picks up where LIN 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 other perspectives are explored when possible. 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 introductory syntax course examines syntactic phenomena from the perspective of phrase structure grammars as opposed to transformational grammars. The course examines and develops phrase structure grammar approaches to standard syntactic problems, contrasting them where appropriate with transformational approaches. No background in either approach is assumed.

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 are helpful but not necessary.

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 M.A. Level
Prerequisite: permission of department.
Credit to be arranged

495. Research at the M.A. Level
Prerequisite: permission of department.
Credit to be arranged

591. Reading Course at the Ph.D. Level
Prerequisite: permission of department.
Credit to be arranged

595. Research at the Ph.D. Level
Prerequisite: permission of department.
Credit to be arranged
**Mathematics**

Professors Cohen, Gage, Gonek (Chair), Greenleaf, Harper, Lavine, Lubkin, Mueller, Neisendorfer, Pizer, Ravenel, Segal

Associate Professors Jochnowitz, Pakianathan

Assistant Professors Geba, Gioev, Salur, Starr, Tucker

Adjunct Professor Moore

Joint Appointment: Professor Clark

Visiting Assistant Professors Haessig, Hahn, Heap, Hladky, Lee, Pearson, Pribble, Vermesi

Professors Emeriti Alling, Gitler, Kemperman, Prill, Raimi, Stein, D. Stone, Watts

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 M.A. 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 M.A. in mathematics and statistics requires 36 credit hours. (Contact the department for the description and program of study.) Joint M.A.s with other departments may be arranged on an individual basis.

The M.S. 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 Ph.D. requires two years of full-time study, including at least five formal courses at the 500 level, plus qualifying examinations and a dissertation. Approximately 10 500-level courses are offered each year. The written portion of the qualifying examination covers MTH 436, 437, 440, 443, 467, 471, and 472. 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 265 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 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.

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. Measure and Integration
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 10 500-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.

518. Topics in Random Matrix Theory
Random matrix theory (RMT) is an area of mathematics which is currently of high interest. One of the main features of RMT is that it provides accurate models for various correlated quantities that describe the behavior of complex systems arising from a broad variety of problems in physics and also in pure and applied mathematics.

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. Algebraic Number Theory
Valuations, ideal number, unit theorem. Geometric applications.

532. Group Theory
Topics on finite groups: permutation groups; simple groups; representation theory; automorphisms, etc. Topics on finitely generated groups and on infinite abelian groups.

533. Algebraic Curves
Prerequisites: MTH 437 and 440.
Affine and projective algebraic curves, Bezout’s Theorem, resolution of singularities, Riemann-Roch Theorem, introduction to algebraic geometry.

534. Introduction to Class Field Theory
Valuated fields (especially number fields, function fields, and their completions). Galois cohomology of groups; local and global aspects of class field theory.

535. Commutative Algebra
Prerequisites: MTH 437 and 443.
Field theory, valuations, local rings, affine schemes. Applications to number theory and geometry.
536. Combinatorial Group Theory
This course deals with methods for studying groups by means of generators and relations. Among the problems considered is the problem of determining presentations for sub-groups, products, extensions, et al, in terms of given presentations. Special groups (e.g., free groups, free products, braid groups) are considered. Whenever possible, topologically motivated proofs and applications are given.

537. Homology
Prerequisite: MTH 436.
Projective and injective modules, complexes and resolutions, derived functors, including Ext and Tor, the homology and cohomology theory of groups and algebras, applications to the extension problem, etc.

538. Topics in Algebraic Geometry I
Prerequisite: MTH 534, 535, or 536.
Spaces with structure sheaf, schemes, cohomology of schemes, applications to algebraic curves and algebraic groups.

539. Topics in Algebraic Geometry II
Local algebra, applications to intersection theory.

540. Introduction to Differential Topology
Prerequisites: MTH 266 and 440.
Manifolds and their differential structures, imbeddings and immersions, vector bundles including tangent and normal bundles, transversality, degree of a map, intersection numbers, Morse theory, cobordism. No knowledge of algebraic topology required.

541. Introduction to Knots and Links
Knots and links in IR³ and S³. Fundamental groups, Seifert surface, matrix invariants, branched covers, elementary 3-manifold theory. Higher dimensional knots.

542. Duality Theory for Manifolds
Prerequisite: MTH 443.
Basic theory of homotopy and homotopy groups. Singular homology and cohomology. The Cech cohomology of sheaves and applications.

543. 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

547. Lie Groups and Algebras
Prerequisite: MTH 237 and 440.

548. 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
Prerequisite: 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. 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.

561. Algebraic Function Theory over Compact Riemann Surfaces
Prerequisites: MTH 436, 437, and 467.
Algebraic curves over \( C \) and compact Riemann surfaces are considered in the context of the cohomology of various algebraic and analytic sheaves. The Riemann-Roch and Serre duality theorems and, if time permits, Weil's lemma and the Weierstrass gap theorems.

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. 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 Atiyah-Singer theorem; includes complete proof of theorem that elliptic pseudodifferential operators are Fredholm.

572. Harmonic Analysis on Symmetric Spaces
Prerequisite: MTH 467.
Fourier analysis on the circle, line, sphere, torus, and hyperbolic space. The trace formulas of Selberg and Kuznetsov with applications to eigenvalues of the Laplacian, Kloosterman sums, and modular forms.

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.
574. Group Representations
Prerequisite: MTH 570.

The representation of topological groups by unitary operators on Hilbert space; classification, decomposition theory, induced representations, duality, group algebras, projective representations.

577. An Introduction to Wavelets
Continuous wavelets transform, windowed Fourier transform, frames, time-frequency density, multi-resolution analysis, orthonormal wavelet bases. Applications.

578. Topics in Harmonic Analysis

579. Topics in Linear PDE

580. Complex Manifolds
Sheaf and differential form cohomology, Kahler geometry, projective manifolds.

581. Several Complex Variables I
Prerequisite: MTH 467.

Holomorphic functions, local rings of holomorphic functions, varieties, analytic sheaves, analytic spaces.

582. Several Complex Variables II
Prerequisite: MTH 581.

Cohomology theory, Stein spaces, pseudoconvexity.

583. Holomorphy
Prerequisite: advanced graduate standing.


584. Mathematical Foundations of Relativity and Quantum Mechanics
Prerequisite: MTH 472.


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 dimensions 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
No credit
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 Ph.D. Level
Prerequisite: permission of department.
Credit to be arranged
Special work for doctoral candidates, arranged individually.

595. Research at the Ph.D. 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
No credit
Weekly lectures by invited speakers on topics of current interest in mathematical research. Required of all students who have completed one year of graduate study.

124 ARTS AND SCIENCES
Philosophy

Professors Braun, Conee, Curren (Chair), Feldman, Holmes, Kyburg, Meerbote, Modrak
Associate Professor Dees
Assistant Professor Ney
Senior Lecturer Bennett
Joint Appointments: Professors Carlson, Wierenga
Professors Emeriti Eberle, 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 Ph.D. 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 M.A. 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. M.A. 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.

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 meta-ethical 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.

423. 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.

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.  
A study of the 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.

452. Philosophy of Science  
Prerequisite: PHL 110 or permission of instructor.  
An examination of scientific theories, nature of causal and statistical explanation.

458. Science and Reason  
Prerequisite: PHL 110 or permission of instructor.  
An examination of such questions as: Is science rational? Is all rationality scientific? Are scientific theories merely instrumental, or do they tell us about Reality? Are there alternatives to science?

460. Contemporary Issues in Philosophical Theology  
A philosophical examination of such theological concepts as original sin, atonement, incarnation, and trinity.

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
511. Logic and Philosophy
512. Problems and Universals
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
524. Morality and War
525. Wittgenstein
526. Theories of Justice
527. Berkeley
529. Rationalism and Empiricism
530. Kant I
531. Kant II
532. Kant III
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
572. Political Philosophy
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 Ph.D. 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 Ph.D. Level
        Credit—varies
999. Writing Dissertation in Residence
        No Credit
Physics and Astronomy

Professors Bigelow, Blackman, Bodek (Chair), Cline, Das, Douglass, Eberly, Ferbel, Forrest, Frank, Gao, Hagen, McFarland, Melissinos, Orr, Rajeev, Shapir, Slattery, Teitel, Thorndike, Watson, Wolf, Wolfe

Associate Professors Demina, Manly, Quillen

Assistant Professors Howell, Jordan

Senior Lecturers/Scientists Auchincloss, Budd, Chung, deBarbaro, Ginther, Park, Sakamoto, Yu, Zielinski

Joint Appointments: Professors Agrawal, Betti, Bocko, Boyd, Conwell (Research), Foster, McCrory, Meyerhofer, Rothenberg, Schroder, Simon (Emeritus), Stroud, Tarduno, Thomas, Zhong

Associate Professor Novotny; Assistant Professor Ren

Visiting Associate Professor: Visser

Visiting Assistant Professors: Buescher, Quadt

Visiting Senior Lecturers/Scientists: Lyutikov, Wu

Director, Mees Observatory: Forrest

Professors Emeriti Castner, Fulbright, Gove, Helfer, Huizenga, Jacobsen, Knox, Koltun, Okubo, Pipher, Savedoff, Sharpless, Sproull, Van Horn

The Department of Physics and Astronomy offers a graduate curriculum leading to a Ph.D. degree in physics and in physics and astronomy. M.S. degrees (under Plan A) and M.A. 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).

Infrared, optical, and radio-observational work in astronomy is conducted at the national observatories. The observational astrophysics group is active in the development of advanced detector arrays and instrumentation for infrared astronomy, and employs these devices with telescopes on high, dry sites, such as Mauna Kea (Hawaii) and Mt. Lemmon (Arizona). Several faculty are involved in space astrophysics research programs such as the NASA Space Infrared Telescope Facility (SIRTF) and the Next Generation Space Telescope (NGST). The University's C. E. K. Mees Observatory, in nearby Bristol Hills, offers a 24-inch telescope and an up-to-date complement of optical imaging and spectroscopic instruments.

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.

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 presently focuses in the areas of surface physics, including studies of interfaces in organic semiconductor devices, the spectroscopy of nanostructures, and ultrafast dynamics of photoexcited electrons. Theoretical work focuses in the areas of statistical mechanics and critical phenomena, with application to phase transitions in random systems, interface growth, transport in disordered media, and vortex fluctuations in high-temperature superconductors and superconducting networks.

A leading program in experimental particle physics is maintained at the antiproton-proton Tevatron Collider of the Fermi National Accelerator Laboratory and at the positron-electron colliding beam facility at the Wilson Laboratory (Ithaca). There are also programs on searches for gravity waves (LIGO), on neutrino interactions at the Fermi National Accelerator Laboratory, on electron scattering at the Jefferson Laboratory, on development of a photoinjector for the next linear collider and electron cooling, and experiments are being prepared for the Large Hadron Collider (LHC) at CERN in Geneva, Switzerland. In high-energy theory, topics currently under investigation include gauge theories, weak interactions, QCD, and general problems in quantum field theory. Research in high-energy nuclear physics is being carried out with the PHOBOS detector at the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory. Besides RHIC, instrumentation developed for nuclear physics is used in experiments at other major accelerator facilities such as Lawrence Berkeley Laboratory and Argonne National Laboratory. Nuclear theory includes research in nuclear structure and reactions and interactions of nuclei with elementary particles.

An active research program in quantum optics covers both theory and experiment. Research topics include quantum imaging, slow/fast light, the coherence properties of electromagnetic fields, spectroscopy with partially coherent sources, the concept of single-photon phase, quantum entanglement, and the interaction between light and atoms including the domain of superstrong laser fields and the single-photon quantum limit. In addition there are also active studies of elementary processes involving photons and atoms, tests of quantum locality violations, quantum information imaging and communication, revivals and quantum interference in atomic and electronic wave packets, sub-Doppler laser cooling and ultracold atom collisions, and Bose-condensation.

High-speed computers at the University are available for use as an adjunct to both experimental and theoretical research. The department maintains its own state-of-the-art computing network for research and administrative needs. The department’s Barnes Computer Center, staffed by two full-time systems managers, provides a convenient central location for department computing equipment. A large public workroom provides workstations, access to the network, Macintosh computers, optical scanning, and color printing. Access is available 24 hours a day. The facilities of the department contain, in addition to research and office space for both staff and graduate students, an up-to-date departmental library.

The cross-disciplinary physics program, and department policy allow students with special interests in the research of faculty members outside the department to obtain a Ph.D. in physics under such external supervision. Theses have been completed in this way in areas of mathematics, biology, optics, electrical engineering, chemistry, and plasma physics. In such cases, the student’s supervision is also shared by an internal advisor from the department. College policy with departmental support allows students to pursue joint Ph.D degrees.

Applicants for admission to graduate work in physics or astronomy should present the equivalent of PHY 217, 218, 227, 235, 238, 243, 247, and MTH 164 and 281–282. Students who do not possess the proper qualifications for admission may be admitted under special circumstances, but will be required to correct all deficiencies during the first year of graduate study. Admission for study in astronomy and astrophysics does not presuppose any special background in astronomy. The number of graduate students admitted each year is limited, with preference given to candidates for the Ph.D. degree. The department offers a variety of support to its students including fellowships and trainee-ships.
Candidates for the Ph.D. 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 Ph.D. 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 Ph.D. examination. Students are encouraged to begin research activity in their first year of study. All Ph.D. 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 Ph.D. 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 B.S.-M.S. program in physics and physics and astronomy. Students who wish to go beyond the bachelor's level may enroll in the department's five-year B.S.-M.S. 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 B.S. is completed by the end of the fourth year, and requirements for the M.S. are completed by the end of the fifth year. The M.S. degree may be pursued via plan A (with master's thesis) or plan B (with comprehensive exam).

The 200- and 300-level courses listed below carry three hours of graduate credit unless otherwise noted.

Physics

217. Electricity and Magnetism I
Prerequisites: PHY 123 or 143; MTH 164.
Review of vector calculus; electrostatic field and potential; boundary value problems solved with orthogonal functions; the multipole expansion and dielectrics; the magnetic field and vector potential.

218. Electricity and Magnetism II
Prerequisites: PHY 217; MTH 164.
Electromagnetic induction; displacement current; Maxwell's equations; the wave equation; plane electromagnetic waves; Poynting vector; reflection and refraction; radiation; transmission lines; propagation of light; radiation by charged particles; relativistic formulation of Maxwell's equations.

227. Thermodynamics and Statistical Mechanics
Prerequisites: PHY 237; 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.

235W. Classical Mechanics 1
Prerequisite: MTH 281 or ME 201 (may be taken concurrently).
Mathematical introduction; review of elementary mechanics; central force problems; conservation theorems and applications; Fourier and Green's functions; variational calculus and
Lagrangian multipliers; Lagrangian and Hamiltonian formulation of mechanics is introduced and applied; oscillations; normal mode theory; rigid body dynamics. This course can be used to satisfy the upper-level writing requirement.

237. Quantum Mechanics of Physical Systems
Prerequisites: PHY 122 or PHY 142; PHY 123 or PHY 143; or permission of the instructor.

Introduction to quantum mechanics with emphasis on applications to physical systems. Includes Schroedinger theory, solutions to the one-dimensional Schroedinger equation, the hydrogen atom, and selected applications from atomic and molecular physics, quantum statistics, lasers, solids, nuclei, and elementary particles.

243. Advanced Experimental Techniques I
Prerequisites: PHY 217, 237 (may be taken concurrently).

Students perform three or four experiments from a variety of available setups such as Berry's phase with light, Universal chaos, lifetime of cosmic ray muons, optical pumping, electron diffractions, etc. This is a hands-on laboratory with most experiments under computer control.

244. Advanced Experimental Techniques II
Prerequisites: PHY 217, 237 (may be taken concurrently).

A continuation of PHY 243 with greater emphasis on independent research and construction of more complicated instrumentation.

246. Quantum Theory
Prerequisites: PHY 237, MTH 281 or equivalent; or consent of instructor.

Formalism of quantum theory with more advanced applications than PHY 237. Includes postulates of quantum mechanics; function spaces, Hermitian operators, completeness of basis sets; superposition, compatible observables, conservation theorems; operations in abstract vector space, spin and angular momentum matrices; addition of angular momentun; perturbation theory and simple scattering theory.

252. Biomedical Ultrasound
(Same as BME 251 and 451)
Prerequisites: MTH 163, 164, and PHY 122 or 142 or permission of instructor.

Course provides analyses of the physical bases for the use of high-frequency sound in medicine (diagnosis, therapy, and surgery) and biology. Topics include acoustic interactions of ultrasound with gas bodies (acoustic cavitation and contrast agents), thermal and nonthermal biological effects of ultrasound, ultrasonography, dosimetry, hyperthermia, and lithotripsy.

255W. Physics in Modern Technology
Prerequisites: PHY 121–123 or PHY 141–143.

Course is designed for science majors interested in the impact of science in modern technology and vice versa. Topics covered are microelectronics and their application to computers: the transistor, manufacture of the transistors and VLSI, computer architecture data representations. Communications: transmission of electromagnetic waves, information theory, noise in communication channels fiber optics communications, principles and properties of laser operation. Energy: solar energy. This course includes a writing component and can be used to satisfy part of the upper-level writing requirement.

256. Computational Physics
Prerequisites: PHY 121–123 or PHY 141–143.

Introduction of numerical and computational methods with special emphasis on their utilities and applications in contemporary physics topics.

261. Physical Optics I (Interference and Diffraction)
(See as OPT 261)
Prerequisites: MTH 164 and PHY 122 or 142.

Complex representation of waves; scalar diffraction theory; Fresnel and Fraunhofer diffraction and application to measurement; diffraction and image formation; optical transfer function; coherent optical systems, optical data processing, and holography.

262. Physical Optics II (Electromagnetic Theory)
(See as OPT 262)
Prerequisites: PHY 122 or 142 and 123 or 143 and MTH 163 and 164.

Continuation of PHY 261. Vector analysis; microscopic and macroscopic forms of Maxwell's equations; energy flow in electromagnetic fields; dipole radiation from Lorentz atoms; partially polarized radiation; spectral line broadening; dispersion; reflection and transmission; crystal optics; electro-optics; introduction to quantum optics.

263. Computational Methods in Optics
(See as OPT 211)
Prerequisites: MTH 162 and concurrent enrollment in MTH 164.

Course introduces techniques transforming continuous problems to discrete mathematical
models. Students learn computational methods for solving problems in optics using high-level software. Includes laboratories.

264. Laser Systems
(Same as OPT 224)
Prerequisites: some knowledge of simple quantum mechanics and scalar diffraction, OPT 241 and 261 or may be taken concurrently, MTH 163 or 165 is recommended.

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 understanding the operation of those currently in use.

276. Medical Optics
(Same as OPT 476)
Prerequisites: PHY 227, 246, and MTH 165 or permission of instructor.

Major topics are biomedical spectroscopy (absorption, fluorescence, Raman, elastic scattering); propagation of photons in highly scattering media (such as tissue); techniques for high-resolution imaging in biological media: confocal imaging, multiphoton imaging, and optical coherence tomography.

401. Complex Analysis and Differential Equations
(Same as OPT 411)
Prerequisites: MTH 164, 282, or equivalent.


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
Prerequisite: PHY 246, or permission of instructor.


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 consent 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 include experimental tests; black holes; relativistic star models; cosmological models; early stages of evolution of the universe; gravitational waves.
415. Electromagnetic Theory I
Prerequisite: PHY 401 or concurrently.

418. Statistical Mechanics I
Prerequisites: PHY 227 or equivalent; PHY 407, 408 concurrently.
Review of thermodynamics; general principles of statistical mechanics; microcanonical, canonical, and grand canonical ensembles; ideal quantum gases; applications to magnetic phenomena, heat capacities, black-body radiation; introduction to phase transitions.

420. Introduction to Condensed Matter Physics
(Same as PHY 251, MSC 420, 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.

421. Seminar in the Physics of Medical Imaging
(Same as PHY 301)
Prerequisite: permission of instructor.
Credit—two hours
Seminar course includes the basic physical theory, mathematics, and instrumentation of medical imaging. The course covers the basic properties of matter, radiation, radioactive decay, X-ray systems, digital imaging systems, nuclear medicine systems, radiobiology, ultrasound systems, and magnetic resonance. This course is offered to radiology residents and restricted to physics students. The course is cross-listed with physics for students who plan to receive a Certificate in Biological or Medical Physics, or students who are in the B.S.-M.S. physics 3-2 program and plan to do an M.S. thesis in medical physics.

422. 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.

423. Reading Course: Topics in Health Physics
Prerequisite: permission of instructor.
Credit—two hours
Course gives students an opportunity to investigate an assortment of topics: history of health physics; interaction of charge particles with matter; operational dosimetry; radiation shielding; theory and practice of radon detection; biological effects of radiation; federal and state regulations.

424. 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.

425. Physics of Radiotherapy I
(Same as PHY 325)
Prerequisite: permission of instructor.
Credit—two hours
Directly and indirectly ionizing radiation use in radiation therapy causing biological damage in the normal tissue and cancer. Radiation delivery techniques are specifically designed and configured to target the neoplasm. The physics of radiation interactions with matter and the clinical use of radiation are presented in this course. The methods of radiation production, measurement of ionizing radiation, absorbed dose as well as the calculation of dose distributions and treatment-planning systems are presented for all radiation modalities. Radiological physics is covered to the extent necessary to explain the use of CT, MR, and PET images as implemented in the treatment planning process.

426. Physics of Radiotherapy II
(Same as PHY 326)
Continuation of 425.

427. Radiobiology I
(Same as PHY 327, BPH 490)
Credit—two hours
Evaluates the effects of radiation in mammalian cell systems ranging from cell cultures to whole animals. Emphasis is on the application of radiobiological principles to radiotherapy practices in the clinical treatment of cancer. Topics include mechanism of radiation damage and
repair, cell cycle effects, influence of oxygen, and tumor versus normal tissue effects of radiation.

428. Radiobiology II
(Same as PHY 328, BPH 490)
Credit—two hours
Continuation of 427.

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.

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)
General principles of spectroscopy focused on interaction of radiation with two-level systems. Spin, rotational, vibrational, and electronic spectroscopies of small and polyatomic molecules are covered. The course also includes an overview of experimental techniques such as nonlinear and transient optical spectroscopy.

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 428)
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; lightweight 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)
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 pertain-
ing to the conservation of quantum numbers and symmetries observed in the high-energy collisions.

446. Nuclear Chemistry 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.

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)

General development of conservation laws and constitutive equations; inviscid flows; vorticity; potential flows; stratified flows; viscosity and Reynolds number; some exact solutions with viscosity; boundary layers; low Reynolds number flows. Selected applications from aerodynamics, blood flow, meteorology, oceanography, and lubrication theory.

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 (M.S.)

Independent investigation leading toward a master's thesis carried out under the supervision of a staff member.

498. Supervised Teaching Assistant I
No credit

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
No credit
Prerequisite: PHY 498

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. Introduction to Quantum Electrodynamics  
Prerequisites: PHY 407, 408, or equivalent.

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.

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, density and distribution functions, moments of a random variable, characteristic and moment generating functions, power or Wiener spectrum, Gaussian processes, Poisson point processes, compound Poisson point processes. Coherence properties of optical fields: temporal coherence, spatial coherence, propagation of the mutual coherence function, Van Cittert-Zernike theorem, effects of partial coherence on imaging systems. Laser speckle and its applications: speckle statistics, addition of speckle patterns, integrated speckle statistics in the far field and in the image plane, space-time correlation functions, speckle velocimetry, and speckle interferometry. Photoelectric detection of light: semiclassical model for photoelectric detection, effects of stochastic fluctuations of classical intensity, interferometry at low-light levels, and pattern recognition using photon-limited images.

538. Advanced Topics in Light-Wave Technologies  
(Same as OPT 528)  
Prerequisite: OPT 461; OPT 428 recommended, but not required.  
This course is design 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, fiber 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 Fridemann-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.

564. Seminar on High-Energy Astrophysics  
(Same as AST 564)  
Prerequisite: AST 461, AST 462.  
A survey of current research reports in scientific journals on topics concerning astrophysical plasma physics, magnetic field-particle interactions, gravitational and general relativity, and early stages of evolution of the universe.

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 Ph.D. 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 Ph.D. Level  
_Credit to be arranged_  
Independent investigation leading toward a doctoral thesis carried out under the supervision of a staff member.

597. Research Seminar  
_No credit_  
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.

Astronomy  

232. The Milky Way Galaxy  
_prerequisites: familiarity with PHY 235 and AST 142 is advised._  
Stellar motions; stellar distances; celestial mechanics; galactic structure; cluster evolution; fundamental equations of stellar statistics.

241. Stellar Astrophysics  
_prerequisites: PHY 237 (may be taken concurrently); familiarity with subject matter of AST 111 and/or AST 142 is advised._  
Taken primarily by juniors and seniors majoring in physics and astronomy, physics, optics, or mathematics. Elements of radiative transfer and gas dynamics are presented and applied to the study of the atmospheres of stars. Interior structure and evolution of stars of various types are also discussed.

AST 242. Astrophysics II  
_prerequisite: PHY 237 (may be taken concurrently); familiarity with the subject matter of AST 142 and/or AST 111 is advised._  

598. Teaching Workshop Leader Pedagogy Training  
_No credit_  
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._  
_No credit_  
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  
_No credit_  
Writing dissertation.

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 Ph.D. 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 Ph.D. Level  
_Credit to be arranged_  
Independent investigation leading toward a doctoral thesis carried out under the supervision of a staff member.

597. Research Seminar  
_No credit_  
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.

Astronomy  

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_prerequisites: familiarity with PHY 235 and AST 142 is advised._  
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Taken primarily by juniors and seniors majoring in physics and astronomy, physics, optics, or mathematics. Elements of radiative transfer and gas dynamics are presented and applied to the study of the atmospheres of stars. Interior structure and evolution of stars of various types are also discussed.

AST 242. Astrophysics II  
_prerequisite: PHY 237 (may be taken concurrently); familiarity with the subject matter of AST 142 and/or AST 111 is advised._  

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_No credit_  
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599. Pedagogy and Group Leadership  
_prerequisite: PHY 598._  
_No credit_  
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  
_No credit_  
Writing dissertation.

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 Ph.D. 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 Ph.D. Level  
_Credit to be arranged_  
Independent investigation leading toward a doctoral thesis carried out under the supervision of a staff member.

597. Research Seminar  
_No credit_  
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.

Astronomy  

232. The Milky Way Galaxy  
_prerequisites: familiarity with PHY 235 and AST 142 is advised._  
Stellar motions; stellar distances; celestial mechanics; galactic structure; cluster evolution; fundamental equations of stellar statistics.

241. Stellar Astrophysics  
_prerequisites: PHY 237 (may be taken concurrently); familiarity with the subject matter of AST 111 and/or AST 142 is advised._  
Taken primarily by juniors and seniors majoring in physics and astronomy, physics, optics, or mathematics. Elements of radiative transfer and gas dynamics are presented and applied to the study of the atmospheres of stars. Interior structure and evolution of stars of various types are also discussed.

AST 242. Astrophysics II  
_prerequisite: PHY 237 (may be taken concurrently); familiarity with the subject matter of AST 142 and/or AST 111 is advised._  

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_No credit_  
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._  
_No credit_  
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  
_No credit_  
Writing dissertation.
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.

This course is an 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  
**Prerequisites:** PHY 407–408, 415, 418, in the past or concurrently.

This year-long course sequence is designed to provide prospective astronomy and astrophysics students with physics tools they need in addition to those taught in the usual physics sequence. Many examples of the use of these tools in astrophysical contexts are provided. The course is designed to be taken starting the fall of the second year of graduate study, and is intended to be intensive.

462. The Physics of Astrophysics II  
**Prerequisite:** AST 461.

Continuation of 461.

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.

551. Diffuse Matter in Space  
**Prerequisite:** permission of instructor.


552. Galactic Dynamics  
**Prerequisite:** AST 461–462 or AST 465.

Boltzmann equation and collision theory. Structure and evolution of clusters, numerical experiments, Galactic hydrodynamics, wave theory of spiral arms, models of galactic nucleus regions, superdense cluster theory.

553. Stellar Interiors  
**Prerequisite:** AST 461–462 or AST 453.


554. Cosmological Physics  
(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. Seminar on High Energy Astrophysics  
(Same as PHY 564)  
**Prerequisites:** AST 461, 462.

A survey of current research reports in scientific journals on topics concerning astrophysical plasma physics, magnetic field-particle interactions, gravitational and general relativity, and early stages of evolution of the universe.
591. Reading Course at the Ph.D. 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 Ph.D. Level
Credit to be arranged
Independent investigation leading toward a thesis carried out under the supervision of a staff member.

999. Doctoral Dissertation
No credit
Writing dissertation.

Political Science

Professors Duggan, Jackson, Jacobs, Niemi, Phelps, G. Powell, L. Powell, Rothenberg, Seligman
Associate Professors Fey, Gamm (Chair), Johnson, Signorino, Stone
Assistant Professors Clarke, Goemans, Helmke, Jordan, Kalandrakis, Kayser, Meguid, Peress, Primo, Sinclair-Chapman
Adjunct Associate Professor Hauser
Professors Emeriti Bluhm, Fenno, Regenstreif

The Department of Political Science offers a program of graduate study leading to the degree Doctor of Philosophy. The primary purpose of the Ph.D. 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.

Ordinarily, only full-time students who intend to work toward the doctorate are admitted. 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. Unless exempted, all students are required to participate in an ungraded “prefresher” math course in the three weeks before the start of the first semester.

Doctoral candidates are required to take PSC 480, 404, 405, 407, 408, and a graduate seminar in political philosophy unless they can show equivalent training in these areas. All doctoral candidates are required to take at least 14 regular courses in the Ph.D. program and qualifying examinations in three fields. The three written comprehensive examinations must be completed prior to the beginning of the seventh semester. The available fields are as follows: American politics, comparative politics, international relations, political philosophy, formal theory, and statistical methods. The fields of formal theory and statistical methods may be taken at either the B (basic) or A (advanced) level, but no more than one field may be taken at the B level. (Also see the W. Allen Wallis Institute on page 148, concerning the interdisciplinary field of political economy.) Students who offer only one substantive field for comprehensive examination must take two substantive courses beyond those required for that field examination.

All candidates for the Ph.D. degree are required to do some supervised teaching as part of the requirements for the degree. Ordinarily, students do not teach in the first year; but in the second and third year, they are required to assist in one of the beginning courses, in PSC 202 or other courses, or in research activities. Advanced students are sometimes given the opportunity to teach a course of their own. At the beginning of the fifth semester, students must complete and present to the faculty a second-year paper that demonstrates their capacity for conducting research. After the completion of other requirements, doctoral candidates must propose, write, and defend an acceptable Ph.D. thesis.
The following courses carry four credit hours, unless otherwise noted. For additional information, please refer to the department Web site: www.rochester.edu/college/PSC.

Methodology

404. Probability and Inference
405. Linear Models

505. Maximum Likelihood Estimation
Prerequisite: PSC 405.

506. Advanced Topics in Methods
Prerequisite: PSC 505 or permission of instructor.

American Politics

510. Political Parties and Elections
512. Voting and Elections
516. Political Participation
518. Emergence of the Modern Congress
519. American Legislative Institutions

523. American Politics Field Seminar
525. Race and Political Representation
530. Urban Change and City Politics
535. Bureaucratic Politics
540. Models in American Politics: Theory and Data

Comparative Politics

453. Comparative Political Parties
550. Comparative Politics Field Seminar
551. Western European Politics
555. Democratic Processes

556. Political Economy of Reform
558. Comparative Parties and Elections
564. Comparative Political Economy

International Relations

471. Russia and Eastern Europe: Politics and International Relations
479. War and the Nation-State
572. International Politics Field Seminar
573. Territory and Group Conflict
574. International Political Economy

576. Modeling International Conflict
577. Theories of Conflict
578. International Conflict: Theory and History
579. Politics of International Finance

Positive Political Theory

407. Mathematical Modeling
408. Positive Political Theory
575. Political Economy I

582. Political Economy II
584. Game Theory
586. Theory of Voting and Elections

Political Philosophy

480. Scope of Political Science
482. Art and Politics
484. Democratic Theory

581. Philosophical Foundations of Political Science
583. Culture and Politics
Other Offerings

491. Reading Course at the Master’s Level
492. Research at the Master’s Level

Center for Visual Science

Professors Aslin, Duffy, Feldon, Fienup, Ison, Jacobs, Knill (Associate Director), Lennie, MacRae, Makous, Merigan, Paige, Pasternak, Schieber, Williams (Director)
Associate Professors Bavelier, Pouget, Weliky
Assistant Professors Freedman, Huxlin, Majewska, Romanski, Seidman, Yoon
Adjunct Professors Cox, Krauskopf, Sterns
Adjunct Assistant Professors Chung, Karn, Pelz, I. Williams
Research Professor Emeritus Emerson

The Center for Visual Science provides specialized coursework and advanced research facilities for graduate students and postdoctoral 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.

Core Courses

504. Sensory Systems
(Same as BCS 504)

505. Perception and Motor Systems
(Same as BCS 505)

526. Principles of Eye Design
(Same as BCS 526 and OPT 448)

528. Special Topics in Vision
(Same as BCS 528)

Visual and Cultural Studies Program

Professors Berlo, Crimp, DiPiero, Duro, Michael, Willis
Associate Professors Halle, Saab
Affiliated faculty: Professors Bernardi, Foster, Gustafson; Associate Professors Kegl, Pedersen, Tucker; Assistant Professors Haidu, Niu

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 22 graduate students in residence in the program.

### Visual and Cultural Studies Colloquium

**AH 583. Colloquium in Visual and Cultural Studies**

#### Core and Elective Courses*

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>AH 412</td>
<td>Modern Architecture</td>
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<tr>
<td>AH 414</td>
<td>Beyond the Boundaries</td>
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<tr>
<td>AH 415</td>
<td>Contemporary Art: Theory and Practice</td>
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<tr>
<td>AH 450</td>
<td>Baroque Art and Culture</td>
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<tr>
<td>AH 455</td>
<td>American Art</td>
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<td>AH 456</td>
<td>Vernacular Architecture in the USA</td>
</tr>
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<td>AH 459</td>
<td>Women, Cloth, and Culture</td>
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<td>AH 463</td>
<td>Twentieth-Century Art and Culture</td>
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<td>AH 462</td>
<td>Impressionism and Post-Impressionism</td>
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<td>AH 466</td>
<td>African-American Visual Culture</td>
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<tr>
<td>AH 474</td>
<td>Cultural History of American Architecture</td>
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<td>AH 477</td>
<td>The Museum and “the Other”</td>
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<td>AH 482</td>
<td>Contemporary Art and Criticism</td>
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<td>AH 487</td>
<td>Culture on Display</td>
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<td>AH 492</td>
<td>The Modern City</td>
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<td>AH 500</td>
<td>Reconsidering Roland Barthes</td>
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<td>AH 506</td>
<td>Sublime in Visual Culture</td>
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<td>AH 507</td>
<td>Rhetoric of the Frame</td>
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<td>AH 508</td>
<td>Art and Imitation</td>
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<td>AH 512</td>
<td>Postwar Art and Theory: The Sixties</td>
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<td>AH 515</td>
<td>Feminism and Visual Culture</td>
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<td>AH 520</td>
<td>The Politics of Space</td>
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<td>AH 525</td>
<td>Contemporary Art and Culture</td>
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<td>AH 568</td>
<td>Art of the Colonial Encounter</td>
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<td>ANT 426</td>
<td>Culture and Consumption</td>
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<td>ANT 466</td>
<td>Global Culture</td>
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<td>ANT 467</td>
<td>Fashion, Beauty, Power</td>
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<td>ANT 551</td>
<td>Meaning and Emotion in Culture</td>
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<tr>
<td>CLT 405C</td>
<td>French Avant-Garde(s)</td>
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<td>CLT 411B</td>
<td>French Film: The New Wave</td>
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<td>CLT 412J</td>
<td>Avant-Garde Film</td>
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<td>CLT 419</td>
<td>Contemporary Popular Film: Race and Gender</td>
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<td>CLT 434</td>
<td>Queer Theory</td>
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<td>CLT 447</td>
<td>Holocaust and After</td>
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<td>CLT 454</td>
<td>Psychoanalysis and Cultural Studies</td>
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<td>CLT 457</td>
<td>Kristeva</td>
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<td>CLT 480</td>
<td>Feminist Film Theory</td>
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<tr>
<td>CLT 481</td>
<td>Popular Film: Sex and Violence</td>
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<td>CLT 481A</td>
<td>Contemporary French Thought</td>
</tr>
<tr>
<td>CLT 481B</td>
<td>Freud, Lacan, and Contemporary Thought</td>
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</tbody>
</table>

* Offerings vary from year to year. Arrangements may be made for directed courses in studio.
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 542. The African-American Postmodern
ENG 552. Post-Colonial Theory
ENG 553. Feminist Theory
HIS 482. Topics in Twentieth-Century American Cultural History
SA 491. Independent Studio
Susan B. Anthony Institute for Gender and Women’s Studies

Professor Susan Gustafson (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 Ph.D.) 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).

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; an historical perspective on 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.
The purpose of the Wallis Institute, a collaborative venture of the economics and political science departments, is to expand our knowledge of the fundamental interactions between institutions and individual behavior in economics and politics. While the behavior of individuals is constrained and shaped by institutions, behavior in the aggregate fundamentally defines institutions. Scholars associated with the Institute study the creation, evolution, and operation of political and economic institutions as well as the behavior of political and economic actors, and will explore how those institutions and behaviors affect public policy and economic performance. A main goal of the graduate program, then, is to produce political economy scholarship and scholars able to hold their own in both disciplines, to make effective use of the complementary tools of the two and to address the problems overlapping the two fields with maximum effect.

Students intending to pursue a Ph.D. with a specialty in political economy register with either the economics or political science departments and take the respective required first-year courses, as they stand now. During the first year, however, students seeking political economy training present a coherent plan of study for the remainder of their time at Rochester. Those accepted spend their second year “off discipline” following the political economy sequence that leads, at the end of the second year, to a field exam in political economy. A “coherent plan of study” minimally includes taking the political economy sequence, discussed below. In addition, students must identify at least one other field offered by either department and prepare a provisional research agenda, in which their knowledge of political economy will be used explicitly. Likely examples of research agendas are the impact on industrial organization of the politics of regulation; the relationship between economic activity and congressional decision making in American politics; and the role of interest group politics in endogenous tariff theory in international trade. Finally, students in political science are also required to take a course in microeconomic theory; economics students are required to take a course in an area of substantive politics related to their research interests. The Ph.D. degree is awarded in either economics or political science, depending on relative specialization in each.

The core of the specialized training program is found in the two-semester political economy seminar. The first semester 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. Thus, for example, 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. The second semester, loosely speaking, covers applied topics. The subject matter of this course changes over time, depending on the specific faculty members involved. For example, there is a rapidly growing literature in economics and in political science devoted to game-theoretic problems of collective choice. Among many other things, this literature treats such topics as regulatory decision making, the endogenous selection of procedural rules in committee decision making, the impact of campaign contributions, and the role of asymmetric information in bureaucratic politics. Regardless of the approach, the intent of the second-semester seminar is to illustrate and reinforce our premise that the traditional boundaries between economics and political science are artificial and that they inhibit the systematic study of rational choice within institution constraints.

At the end of the summer of the second year, students in the program are required to take a comprehensive exam in political economy. By scheduling the exam at this time, all political economy students will be in a position to start research work that exploits the political economy component of their training to date. The comprehensive exam is jointly set and graded by those faculty from both departments primarily involved in the teaching. Similarly, students writing doctoral dissertations in political economy can expect to have at least one committee member from each department.
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 covering topics such as implementation, strategic voting, two-candidate elections, agenda setting, and bargaining. (Fall)

582. Political Economy II
Prerequisite: PEC 575 is recommended (but not necessary).
Political economy is a broad field in the boundaries of political science and economics that emphasizes the interplay of political and economic forces in shaping distribution and efficiency in societies. This course focuses on contributions that emphasize political/distributional aspects and the role of institutions in shaping social outcomes. Topics include parliamentary government; endogenous legislative organization (rules of procedure, seniority, committees); debate and information; lobbying; political parties; courts; bureaucracy; formation and breakup of nation-states; federalism; etc. Emphasis may vary with the configuration of class interests. Research directions are discussed. (Spring)
The College
School of Engineering and Applied Sciences

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Kevin J. Parker, Ph.D. . . . Dean of the School
Thomas Y. Hsiang, Ph.D. . . . Associate Dean for Undergraduate Programs

SEAS COMMITTEE ON GRADUATE STUDIES
Professors Betti, Feldman, Fienup, McGrath, Yates: Dean Slattery (ex officio) and
University Dean of Graduate Studies Jacobs (ex officio)

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and Senior Scientist in the Laboratory for Laser Energetics
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Biomedical Engineering
Victor Derefa, M.E. (Virginia) . . . Adjunct Professor of Electrical and Computer Engineering
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Electrical and Computer Engineering
Joseph Eberly, Ph.D. (Stanford) . . . Andrew Carnegie Professor of Physics and Professor of Optics
Richard F. Eisenberg, M.S. (Rochester) . . . Professor Emeritus of Chemical Engineering
James M. Farrar, Ph.D. (Chicago) . . . Professor of Chemistry
Philippe Fauchet, Ph.D. (Stanford) . . . Distinguished Professor of Electrical and Computer Engineering,
Professor of Materials Science, of Optics, and of Biomedical Engineering and Senior Scientist in the
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Martin R. Feinberg, Ph.D. (Princeton) . . . Professor Emeritus of Chemical Engineering
Marc Feldman, Ph.D. (California, Berkeley) . . . Senior Scientist and Professor (Research) of Electrical and Computer Engineering
†Bruce M. Fenton, Ph.D. (California, San Diego) . . . Professor of Radiation Oncology and of Biomedical Engineering
John R. Ferron, Ph.D. (Wisconsin) . . . Professor Emeritus of Chemical Engineering
James R. Fienup, Ph.D. (Stanford) . . . Robert E. Hopkins Professor of Optics, Professor in the Center for Visual Science and Senior Scientist in the Laboratory for Laser Energetics
Thomas H. Foster, Ph.D. (Rochester) . . . Professor of Imaging Sciences, of Physics, and of Optics
Adam Frank, Ph.D. (Washington) . . . Professor of Physics and Astronomy and Scientist in the Laboratory for Laser Energetics
Eby G. Friedman, Ph.D. (California, Irvine) . . . Distinguished Professor of Electrical and Computer Engineering and Director of the Center for Electronic Imaging Systems
†Robert D. Frisina, Ph.D. (Syracuse) . . . Professor of Surgery, of Neurobiology and Anatomy, and of Biomedical Engineering
Paul D. Funkenbusch, Ph.D. (Michigan Technological University) . . . Professor of Mechanical Engineering and of Materials Science
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Roger F. Gans, Ph.D. (California, Los Angeles) . . . Professor of Mechanical Engineering
Yongli Gao, Ph.D. (Purdue) . . . Professor of Physics
*Victor L. Genberg, Ph.D. (Case) . . . Professor of Mechanical Engineering
Nicholas George, Ph.D. (California Institute of Technology) . . . Professor of Optics and Wilson Professor in Electronic Imaging
M. Parker Givens, Ph.D. (Cornell) . . . Professor Emeritus of Optics
Leonard M. Goldman, Ph.D. (Rochester) . . . Professor Emeritus of Mechanical Engineering
Douglas S. Goodman, Ph.D. (Arizona) . . . Adjunct Professor of Optics
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*Jehuda Greener, Ph.D. (Massachusetts) . . . Adjunct Professor of Chemical Engineering
David R. Harding, Ph.D. (Cambridge) . . . Senior Scientist in the Laboratory for Laser Energetics and Professor of Chemical Engineering
Robert E. Hopkins, Ph.D. (Rochester) . . . Professor Emeritus of Optics
Thomas Y. Hsiang, Ph.D. (California, Berkeley) . . . Professor of Electrical and Computer Engineering
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Edwin Kinnen, Ph.D. (Purdue) . . . Senior Scientist and Professor Emeritus of Electrical and Computer Engineering
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Robert L. McCrory, Ph.D. (M.I.T.) . . . Professor of Mechanical Engineering and of Physics and Astronomy and Senior Scientist in the Laboratory for Laser Energetics; Vice Provost and Director and CEO of the Laboratory for Laser Energetics

* Part-time
† Primary appointment in the School of Medicine and Dentistry
David D. Meyerhofer, Ph.D. (Princeton) . . . Professor of Mechanical Engineering and of Physics and Senior Scientist in the Laboratory for Laser Energetics; Director of the Experimental Division
Gautam Mitra, Ph.D. (Johns Hopkins) . . . Professor of Geology
Duncan T. Moore, Ph.D. (Rochester) . . . Rudolph and Hilda Kingslake Professor of Optical Engineering and Professor of Optics and of Biomedical Engineering
†Ruola Ning, Ph.D. (Utah) . . . Professor of Imaging Sciences, of Oncology, of Radiation Oncology, of Biomedical Engineering, and of Electrical and Computer Engineering
†Gary D. Paige, M.D. (Chicago) . . . Kilian J. and Caroline F. Schmitt Professor of Neurobiology and Anatomy, Professor of Neurology, of Ophthalmology, of Biomedical Engineering, of Surgery, of Brain and Cognitive Sciences, and in the Center for Visual Science
Kevin J. Parker, Ph.D. (M.I.T.) . . . William F. May Professor of Engineering and Professor of Electrical and Computer Engineering, of Imaging Sciences, and of Biomedical Engineering; Director, Rochester Center for Biomedical Ultrasound
Alex P. Pentland, Ph.D. (M.I.T.) . . . Adjunct Professor of Electrical and Computer Engineering
Renato Perucchio, Ph.D. (Cornell) . . . Professor of Mechanical Engineering and of Biomedical Engineering and Associate Professor of Pediatrics
†J. Edward Puzas, Ph.D. (Rochester) . . . Professor of Orthopaedics, of Biochemistry and Biophysics, and of Biomedical Engineering
David J. Quesnel, Ph.D. (Northwestern) . . . Professor of Mechanical Engineering and of Materials Science
Lewis Rothberg, Ph.D. (Harvard) . . . Professor of Chemistry, of Chemical Engineering, and of Physics
Howard Saltsburg, Ph.D. (Boston) . . . Professor Emeritus of Chemical Engineering
†Ingrid H. Sarelius, Ph.D. (Auckland) . . . Professor of Pharmacology and Physiology and of Biomedical Engineering
†Michael C. Schell, Ph.D. (Wisconsin-Madison) . . . Professor of Radiation Oncology, of Cancer Center, and of Biomedical Engineering
Sidney Shapiro, Ph.D. (Harvard) . . . Professor Emeritus of Electrical and Computer Engineering
†Jonathan Shapir, Ph.D. (Tel Aviv) . . . Professor of Physics and of Chemical Engineering
Albert Simon, Ph.D. (Rochester) . . . Professor Emeritus of Mechanical Engineering and of Physics and Senior Scientist in the Laboratory for Laser Energetics
Roman I. Sobolewski, Ph.D. (Polish Academy of Sciences) . . . Professor of Electrical and Computer Engineering and of Materials Science and Senior Scientist in the Laboratory for Laser Energetics
Carlos R. Stroud, Jr., Ph.D. (Washington) . . . Professor of Optics and of Physics
Ching W. Tang, Ph.D. (Cornell) . . . Professor of Chemical Engineering and of Chemistry
Kenneth J. Teegarden, Ph.D. (Illinois) . . . Professor of Optics
Stephen L. Teitel, Ph.D. (Cornell) . . . Professor of Physics
A. Murat Tekalp, Ph.D. (RPI) . . . Adjunct Professor of Electrical and Computer Engineering
John H. Thomas, Ph.D. (Purdue) . . . Professor of Mechanical and Aerospace Sciences and of Astronomy
Brian J. Thompson, Ph.D. (Manchester) . . . Professor Emeritus of Optics
Edward L. Titlebaum, Ph.D. (Cornell) . . . Professor of Electrical and Computer Engineering
Robert C. Waag, Ph.D. (Cornell) . . . Arthur Gould Yates Professor of Electrical and Computer Engineering and Professor of Imaging Sciences
Ian A. Walmsley, Ph.D. (Rochester) . . . Adjunct Professor of Optics
†Denham S. Ward, M.D. (Miami, Florida) . . . Professor of Anesthesiology and of Biomedical Engineering
Dan Watson, Ph.D. (California, Berkeley) . . . Professor of Physics and Astronomy
†Richard E. Waugh, Ph.D. (Duke) . . . Professor of Biomedical Engineering, of Pharmacology and Physiology, of Biochemistry and Biophysics, and of Mechanical Engineering
Gary W. Wicks, Ph.D. (Cornell) . . . Professor of Optics; Associate Director of The Institute of Optics
David R. Williams, Ph.D. (California, San Diego) . . . William G. Allyn Professor of Medical Optics and Professor of Brain and Cognitive Sciences, of Optics, of Psychology, in the Center for Visual Science, of Ophthalmology, and of Biomedical Engineering; Director of the Center for Visual Science
Emil Wolf, D.Sc. (Edinburgh) . . . Wilson Professor of Optical Physics and Professor of Optics
J. H. David Wu, Ph.D. (M.I.T.) . . . Professor of Chemical Engineering, of Microbiology and Immunology, and of Biomedical Engineering
†Jianhui Zhong, Ph.D. (Brown) . . . Professor of Imaging Sciences, of Biomedical Engineering, and of Physics

David H. Albonesi, Ph.D. (Massachusetts) . . . Adjunct Associate Professor of Electrical and Computer Engineering
Andrew J. Berger, Ph.D. (M.I.T.) . . . Associate Professor of Optics and of Biomedical Engineering
Thomas G. Brown, Ph.D. (Rochester) . . . Associate Professor of Optics and Scientist in the Laboratory for Laser Energetics
†Patricia R. Chess, M.D. (Columbia) . . . Associate Professor of Pediatrics and of Biomedical Engineering
Diane Dalecki, Ph.D. (Rochester) . . . Associate Professor of Biomedical Engineering and of Electrical and Computer Engineering
†Edward G. Freedman, Ph.D. (Pennsylvania) . . . Associate Professor of Neurobiology and Anatomy and of Biomedical Engineering and Assistant Professor in the Center for Visual Science
Wendi Heinzelman, Ph.D. (M.I.T.) . . . Associate Professor of Electrical and Computer Engineering and of Computer Science
†Denise C. Hocking, Ph.D. (Albany) . . . Associate Professor of Pharmacology and Physiology and of Biomedical Engineering
Michael R. King, Ph.D. (Notre Dame) . . . Associate Professor of Biomedical Engineering and of Chemical Engineering
Amy Lerner, Ph.D. (Michigan) . . . Associate Professor of Biomedical Engineering, of Mechanical Engineering, and in the Center for Musculoskeletal Research
†Thomas W. Morris, Ph.D. (Michigan) . . . Associate Professor of Imaging Sciences
Anne E. Luebke, Ph.D. (Johns Hopkins) . . . Associate Professor of Biomedical Engineering and of Neurobiology and Anatomy
†Benjamin L. Miller, Ph.D. (Stanford) . . . Associate Professor of Dermatology, of Biochemistry and Biophysics, and of Biomedical Engineering
Jack G. Mottley, Ph.D. (Washington University) . . . Associate Professor of Electrical and Computer Engineering and of Biomedical Engineering
Lukas Novotny, Ph.D. (Swiss Federal Institute of Technology) . . . Associate Professor of Optics, of Biomedical Engineering, and of Physics and Scientist in the Laboratory for Laser Energetics
†Edward M. Schwarz, Ph.D. (Albert Einstein College of Medicine) . . . Associate Professor of Orthopaedics, of Microbiology and Immunology, of Urology, of Pathology and Laboratory Medicine, and of Biomedical Engineering
Wolf Seka, Ph.D. (Texas, Austin) . . . Senior Scientist in the Laboratory for Laser Energetics and Associate Professor of Optics
Gaurav Sharma, Ph.D. (North Carolina State University, Raleigh) . . . Associate Professor of Electrical and Computer Engineering
Hong Yang, Ph.D. (Toronto) . . . Associate Professor of Chemical Engineering
Matthew Yates, Ph.D. (Texas-Austin) . . . Associate Professor of Chemical Engineering
†Wojciech Zareba, M.D. (Lodz, Poland) . . . Associate Professor of Medicine and of Biomedical Engineering
James M. Zavislan, Ph.D. (Rochester) . . . Associate Professor of Optics, of Biomedical Engineering, of Dermatology, and of Ophthalmology; Director of Institute Ventures
Miguel Alonso, Ph.D (Rochester) . . . Assistant Professor of Optics
Paul Ampadu, Ph.D. (Cornell) . . . Assistant Professor of Electrical and Computer Engineering

* Part-time
† Primary appointment in the School of Medicine and Dentistry
Mitchell Anthamatten, Ph.D. (M.I.T.) . . . Assistant Professor of Chemical Engineering and Scientist in the Laboratory for Laser Energetics
Ahmet Becene, Ph.D. (Rochester) . . . Adjunct Assistant Professor of Mechanical Engineering
Hani A. Awad, Ph.D. (Cincinnati) . . . Assistant Professor of Biomedical Engineering and of Orthopaedics
Julie L. Bentley, Ph.D. (Rochester) . . . Adjunct Assistant Professor of Optics
Edward B. Brown, Ph.D. (Cornell) . . . Assistant Professor of Biomedical Engineering
Dale A. Buralli, Ph.D. (Rochester) . . . Adjunct Assistant Professor of Optics
†Kevin A. Davis, Ph.D. (Boston) . . . Assistant Professor of Biomedical Engineering and of Neurobiology and Anatomy
†Lisa A. DeLouise, Ph.D. (Pennsylvania State) . . . Assistant Professor of Dermatology and of Biomedical Engineering
*David Foster, Ph.D. (Rochester) . . . Adjunct Assistant Professor of Chemical Engineering
†Greg T. Gdowski, Ph.D. (Boston) . . . Assistant Professor of Biomedical Engineering and of Neurobiology and Anatomy
*Valerie N. Goncharov, Ph.D. (Rochester) . . . Adjunct Assistant Professor of Mechanical Engineering and Scientist in the Laboratory for Laser Energetics
Chunlei Guo, Ph.D. (Connecticut) . . . Assistant Professor of Optics
Jeff Houck, Ph.D. (Iowa) . . . Adjunct Assistant Professor of Biomedical Engineering
Michael Huang, Ph.D. (Illinois, Urbana-Champaign) . . . Assistant Professor of Electrical and Computer Engineering and of Computer Science
Zeljko Ignjatovic, Ph.D. (Rochester) . . . Assistant Professor of Electrical and Computer Engineering
Nicholas N. Kuzma, Ph.D. (Yale) . . . Assistant Professor of Biomedical Engineering and of Imaging Sciences
Martin Margala, Ph.D. (Alberta) . . . Assistant Professor of Electrical and Computer Engineering
*Andrei Maximov, Ph.D. (Lebedev Physics Institute of Russia) . . . Adjunct Assistant Professor of Mechanical Engineering and Scientist in the Laboratory for Laser Energetics
Stephen McAleavey, Ph.D. (Rochester) . . . Assistant Professor of Biomedical Engineering and of Electrical and Computer Engineering
James L. McGrath, Ph.D. (Harvard-M.I.T.) . . . Assistant Professor of Biomedical Engineering
Vladimir Misic, Ph.D. (Rochester) . . . Adjunct Assistant Professor of Electrical and Computer Engineering
†Walter O’Dell, Ph.D. (Johns Hopkins) . . . Assistant Professor of Radiation Oncology and of Biomedical Engineering
†David J. Pinto, Ph.D. (Pittsburgh) . . . Assistant Professor of Biomedical Engineering and of Neurobiology and Anatomy
Chuang Ren, Ph.D. (Wisconsin-Madison) . . . Assistant Professor of Mechanical Engineering and of Physics and Scientist in the Laboratory for Laser Energetics
Keith Schneider, Ph.D. (Rochester) . . . Assistant Professor (Research) in the Center for Brain Imaging and of Biomedical Engineering
†Scott H. Seidman, Ph.D. (Case Western) . . . Assistant Professor of Biomedical Engineering and of Neurobiology and Anatomy, and in the Center for Visual Science
Azadeh Vosoughi, Ph.D. (Cornell) . . . Assistant Professor of Electrical and Computer Engineering
Hui Wu, Ph.D. (California Institute of Technology) . . . Assistant Professor of Electrical and Computer Engineering
†Gyeunyoung Yoon, Ph.D. (Osaka Univ., Japan) . . . Assistant Professor of Ophthalmology and of Biomedical Engineering
Ping Zhu, Ph.D. (Rochester) . . . Adjunct Assistant Professor of Mechanical Engineering
Thomas R. Boehly, Ph.D. (Rochester) . . . Senior Scientist in the Laboratory for Laser Energetics
R. Stephen Craxton, Ph.D. (Imperial College) . . . Senior Scientist in the Laboratory for Laser Energetics
Jacques Delettrez, Ph.D. (California, Davis) . . . Senior Scientist in the Laboratory for Laser Energetics
William Donaldson, Ph.D. (Cornell) . . . Scientist in the Laboratory for Laser Energetics
Reuben Epstein, Ph.D. (Stanford) . . . Senior Scientist in the Laboratory for Laser Energetics
Vladimir Glebov, Ph.D. (Institute for High Energy Physics) . . . Senior Scientist in the Laboratory for Laser Energetics
Hu Huang, Ph.D. (Rochester) . . . Scientist in the Laboratory for Laser Energetics
Paul A. Jaanimagi, Ph.D. (Waterloo) . . . Senior Scientist in the Laboratory for Laser Energetics
Robert Keck, Ph.D. (Rochester) . . . Senior Scientist in the Laboratory for Laser Energetics
John Kelly, Ph.D. (Rochester) . . . Senior Scientist in the Laboratory for Laser Energetics
James P. Knauer, Ph.D. (Hawaii) . . . Senior Scientist in the Laboratory for Laser Energetics
Robert Kremens, Ph.D. (N.Y.U.) . . . Scientist in the Laboratory for Laser Energetics
Semyon Papernov, Ph.D. (Latvian U. Riga) . . . Scientist in the Laboratory for Laser Energetics
Sean P. Regan, Ph.D. (Johns Hopkins) . . . Scientist in the Laboratory for Laser Energetics
Alexander Ryskin, Ph.D. (USSR Academy of Sciences) . . . Scientist in the Laboratory for Laser Energetics
Ansgar Schmid, Ph.D. (Tech. U. Vienna) . . . Scientist in the Laboratory for Laser Energetics
Robert Short, Ph.D. (Wisconsin) . . . Senior Scientist in the Laboratory for Laser Energetics
Stanley Skupsky, Ph.D. (Chicago) . . . Senior Scientist and Director of Theory in the Laboratory for Laser Energetics
John M. Soures, Ph.D. (Rochester) . . . Senior Scientist in the Laboratory for Laser Energetics
Christian Stoeckl, Ph.D. (Technische Hochschule Darmstadt) . . . Scientist in the Laboratory for Laser Energetics
Ben W. Ebenhack, M.S. (Wyoming). . . Senior Lecturer in Chemical Engineering
*Justin Z. Gao, Ph.D. (Northwestern). . . Lecturer in Mechanical Engineering
*Robert J. Kleckner, Ph.D. (Columbia) . . . Lecturer in Mechanical Engineering
James B. Oliver, M.S. (Rochester) . . . Research Engineer in the Laboratory for Laser Energetics and Lecturer in The Institute of Optics
*Craig Ronald, M.S. (Rochester) . . . Associate Lecturer in Mechanical Engineering
Thor O. Olsen, M.S. (Norway Institute of Technology) . . . Instructor in Chemical Engineering
*Michael Weinstein, M.S. (Rochester) . . . Adjunct Instructor in Chemical Engineering
*Steven Weinstein, Ph.D. (Pennsylvania) . . . Adjunct Instructor in Chemical Engineering

* Part-time
† Primary appointment in the School of Medicine and Dentistry

154 SCHOOL OF ENGINEERING AND APPLIED SCIENCES
Degree Programs

The School of Engineering and Applied Sciences offers academic graduate research programs leading to Master of Science and Doctor of Philosophy degrees. Areas of study include biomedical engineering, chemical engineering, electrical engineering, materials science, mechanical engineering, and optics.

Regulations governing graduate study in the School of Engineering and Applied Sciences correspond to the general regulations for graduate work in the College and other schools of the University as presented on pages 31–66 of this bulletin. Additional requirements and restrictions are presented below and in the sections for each department.

Admission Requirements

Candidates for admission to graduate work must hold a bachelor’s degree or equivalent in one of the branches of engineering, or in physics, chemistry, geological sciences, or mathematics, and must satisfy the cognizant department and the dean for graduate studies that their ability and training are adequate to ensure a reasonable chance for success in work at the graduate level. Full-time admission is normally granted only in the first semester of each academic year. Under certain circumstances some of the work in the Ph.D. program may be pursued on a part-time basis.

Degree Requirements

A graduate student in the School of Engineering and Applied Sciences who has received a grade of C in more than one course in an approved graduate degree program will not be granted a degree. Exceptions may be authorized by the dean for graduate studies on petition of a department chair.

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 College Dean for 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. The official transcript will show only the final grade the instructor assigns although the advising record will indicate an I and the final grade.

University regulations that apply to the Master of Science and Doctor of Philosophy degrees are enumerated earlier in this bulletin under the heading Graduate Degrees. In particular, the Doctor of Philosophy degree 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 Master of Science degree is open to either full-time or part-time students and requires a minimum of 30 hours beyond the bachelor’s degree. Each department has its own special rules regarding the courses that must be taken to earn the M.S. degree.
Engineering involves the judicious application of fundamental scientific principles toward the solution of complex, open-ended problems. This skill requires not only the mastery of a broad base of science and technology, but also experience in the critical examination of contemporary problems in the pertinent discipline. Intensive effort on a research project that culminates in the writing of an M.S. thesis under Plan A is an ideal way to develop the skills required to formulate and execute strategies for the solution of complex problems. In a Plan A master's degree program, the student takes a minimum of 18 credit hours of formal coursework exclusive of reading courses and research. An important component of this 30-hour program is research.

Alternatively, as part of a coursework (Plan B) master's degree program in the School of Engineering and Applied Sciences at Rochester, experience in the methodology of formulating well-posed problems can be obtained to a limited extent through independent study courses such as reading courses, research, and the master's essay. To earn a master's degree via Plan B, the student's 30-hour program of study must include at least 24 credit hours of formal coursework exclusive of reading and research courses and an essay. This formal coursework must be consistent with the rules of the individual departments governing M.S. degrees. In addition, the student may choose to supplement the formal coursework with some form of independent study. However, to receive official approval of this program of study from the dean for graduate studies, the independent study must culminate in a written report or oral presentation (a seminar) which is acceptable to the department.

Part-time students who are admitted under Plan A may complete the thesis in one of three ways:

1. An analytical study which does not require laboratory facilities.
2. An experimental study done in the University laboratories using concentrated blocks of time during vacation periods or, with the cooperation of the employer, during release time.
3. An experimental study done at an approved industrial laboratory under the joint direction of a specially designated member of the laboratory staff and a member of the faculty of the School of Engineering and Applied Sciences. The student will be expected to consult with the faculty advisor at regular intervals regarding the progress of the work.

Classified projects are not accepted as thesis projects, since the results cannot be published.

Students pursuing Plan B master's degrees must pass a departmental comprehensive examination. Any student who fails the comprehensive examination must obtain permission of the department before taking the examination a second time. More than one repetition of the examination is not permitted.

Graduate courses in the School of Engineering and Applied Sciences are frequently offered in the late afternoon or evening hours; courses offered in the day normally are not repeated in the evening in any given semester. Part-time students are urged to consult with their employers concerning the possibility of obtaining release time when it may be necessary to take a course that is offered during the day.
Programs of Study and Thesis Supervision

Each graduate student in the School of Engineering and Applied Sciences is assigned a faculty advisor who helps the student plan an academic program of coursework and research, consistent with departmental and college requirements and the student's educational objectives. The program of study for the degree Doctor of Philosophy must be submitted for the approval of the dean for graduate studies no later than two years after initial registration as a matriculated student, and it must be approved prior to taking the Ph.D. qualifying examination. Programs of study for the Ph.D. degree contain a balance between coursework and research. Typically, 90-credit-hour programs include at least 40 hours of graduate-level coursework (400/500 level).

The program of study for the degree Master of Science must be submitted for the approval of the dean of graduate studies within two semesters of matriculation.

Ph.D. students must complete all formal requirements for the Admission to Candidacy within three years of their matriculation at the University of Rochester. Students who fail to achieve candidacy within the three-year period must petition for an extension to the department chair and the dean for graduate studies. An extension of the time to achieve candidacy may last no more than one year. Additional extensions may be granted under exceptional circumstances.

Each graduate student who has passed the qualifying examination for the Ph.D. has a research advisory committee consisting of the thesis advisor as chair, another full-time faculty member of the student's department, and a full-time faculty member from another department.

Senior research staff members of the School represent a valuable pool of knowledge and experience in research. Such staff members are encouraged to interact with those graduate students who have passed the Ph.D. qualifying examination and who are involved in their thesis research. It is the responsibility of full-time professors to serve as thesis advisors and to have ultimate responsibility for supervising the students' academic and research work.

Biomedical Engineering

Assistant Professors Awad, *Berger, Brown, Davis, *DeLouise, Gdowski, Kuzma, McAleavy, McGrath, *O'Dell, Pinto, Seidman, *Yoon
Assistant Professor (Research) *Schneider
Adjunct Assistant Professor Houck

The Department of Biomedical Engineering administers programs leading to both master's (M.S.) and doctoral (Ph.D.) degrees in biomedical engineering. The graduate faculty in biomedical engineering include members with primary appointments in the Department of Biomedical Engineering as well as members with appointments in other departments, especially in the School of Engineering and Applied Sciences.

* Primary appointment in another department
of Engineering and Applied Sciences and the School of Medicine and Dentistry. These faculty are engaged in research that combines engineering expertise and knowledge of biological and medical systems to advance our knowledge and understanding of biomedical science and technology.

Biomedical engineering (BME) can be defined, very generally, as the application of engineering methods and principles to the solution of medical and biological problems. The field of biomedical engineering is a broad one, with diverse areas of specialization. Biomedical engineers can choose from a wide range of careers, from basic BME research to clinical applications, such as the development of new medical therapies, or the design, development, and production of artificial organs or health care equipment. To prepare students in this highly interdisciplinary field, the educational program provides training to ensure a solid foundation in both engineering principles and in biological sciences. Integration of engineering and biomedical science is facilitated at Rochester by the high degree of interaction and adjacent location of the School of Engineering and Applied Sciences and the School of Medicine and Dentistry. Research strengths include, but are not limited to, the areas of biomedical imaging, neuroengineering, biomedical optics, biomechanics, and molecular, cell, and tissue engineering.

Admission criteria reflect the interdisciplinary nature of BME. Entering students typically hold a B.S. in engineering, mathematics, physics, or chemistry. Some experience with biology and biochemistry is desirable. Perhaps the most important consideration is evidence of a high degree of achievement in undergraduate work. Students who desire to pursue the Ph.D. are most strongly encouraged to apply. In the case of students who wish to undertake a combination of medical and graduate study in the M.D./Ph.D. Program (limited to U.S. citizens and permanent residents with exceptional qualifications), applications should be submitted separately to the Medical Admissions Committee in the School of Medicine and Dentistry with the desire for BME-related Ph.D. thesis research stated on the application form. Further information about BME-related research at Rochester and current program requirements can be obtained prior to application on the Web at www.bme.rochester.edu or by writing to the Director of Graduate Studies, Department of Biomedical Engineering, Box 639, University of Rochester, Rochester, NY 14642-8639.

418. Introduction to Neuroengineering
This course covers computation aspects of neuroengineering research. The course begins with a brief overview of Hodgkin-Huxley channel dynamics, and extends to advanced topics including cable equations, neural circuits and control systems, and biologically plausible neural models of behavior. There is an emphasis on simulation and modeling of both single neural networks and systems.

442. Cell Motility and Molecular Machines
From single molecule motors transporting materials within cells to contracting muscle fibers, molecular engines come in a range of sizes and produce some of the most fascinating phenomena in biology. This course teaches the modern theories behind molecular engines, presuming only an elementary background in cell biology and mechanics. Biology and analysis are combined to examine a few molecular engines in depth. The engines examined vary by year but can include microtubule motors, RNA polymerase, phagocytosis, actin-based Listeria motility, bacterial and mammalian cell chemotaxis, and muscle contraction.

451. Biomedical Ultrasound
(Also 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 surgery, lithotripsy.

452. Medical Imaging—Theory and Implementation
(Also as ECE 452, OPT 452, PHY 422)
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
(Same 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.

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.

466. Fluid Flow in Microchannels
(Same as CHE 466)
Prerequisites: MTH 163/165, MTH 164, CHE 243 or equivalent.
This course examines the unique physics of fluid flow and mass transport in microscale geometries. Such behavior is relevant to many engineering applications from microelectronics cooling to lab-on-a-chip biotechnology. Specific topics include electrokinetic effects on fluid flow, the motion of small suspended particles, and microscale bioreactors.

483. Biosolid Mechanics
(Same 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.

484. Vascular Biology
(Same as PHP 440)
Prerequisites: graduate physiology recommended; permission of instructor required.
An examination of microcirculatory systems and the transport phenomena that occur there. Topics include network architecture (adaptive and pathological changes, models); hemodynamics (roles of blood cell deformabilities, aggregation, cytocris); mechanisms of vascular control; endothelial function; regulation of leukocyte-endothelial interactions; oxygen transport.

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. Our approach is to explore mathematical descriptions of the physical properties biomembrane structures. Basic aspects of the structure and composition of cell membranes are reviewed as a basis for the mathematical treatments.

486. Finite Elements
(Same as ME 441)
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 and geometry; global analysis aspects; isoparametric elements; Galerkin method; biomechanical applications. Term project requires the implementation of a finite element program.

487. Nonlinear Finite Element Analysis
(Same as ME 458)
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, rubberlike materials, biomechanical materials, solution methods.
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.

503. Introduction to Faculty

Faculty provide an overview of research activities along with ideas for thesis and rotation projects.

511. Cellular and Molecular Foundations

Cellular and molecular biology principles geared toward graduate students without detailed background in biological sciences.

513. MR Imaging: From Spins to Brains

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 Cortical Movement

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.

517. Sensory Transduction

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. Each BME graduate student taking this course as an intensive creates a mathematical model of one transduction pathway.

589. Writing Proposals in BME

This course covers the essential aspects of organization and content for writing formal scientific proposals. Open to second-year Ph.D. 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 Ph.D. research.
Rochester Center for Biomedical Ultrasound

Director: Kevin J. Parker (Electrical and Computer Engineering); Associate Director: Deborah J. Rubens (Imaging Sciences); Executive Committee: Diane Dalecki (Biomedical Engineering), Vikram S. Dogra (Imaging Sciences)

Affiliated University of Rochester departments: anesthesiology, biochemistry/biophysics, biomedical engineering, biostatistics, cardiology, chemistry, dermatology, electrical and computer engineering, gastroenterology unit, laboratory animal medicine, mechanical engineering, obstetrics and gynecology, ophthalmology, pathology, physical medicine/rehabilitation, radiation oncology, radiology, surgery, urology, and vascular medicine.

The Rochester Center for Biomedical Ultrasound (RCBU), created in 1986, unites professionals from both the medical and engineering communities, including more than 75 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. The RCBU does not offer independent degree programs. At the Center, professionals join together to investigate clinical applications of very high-frequency sound waves along with other medical imaging and bioeffects endeavors. The Center sponsors seminars, international workshops, and courses for the advancement of diagnostic and clinical ultrasound which are announced to the greater ultrasound community throughout the year. The uses for ultrasound continue to expand as technology advances and as health care providers persevere in the search for more efficient, cost-effective imaging modalities. 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 Web site at www.ece.rochester.edu/users/rcbu.

Laboratory for Laser Energetics

The Laboratory for Laser Energetics (LLE) is a unique national resource for advanced research and education in technology related to the application of high-power lasers. The Laboratory has the five-fold mission to: (1) conduct basic physics experiments; (2) provide education and training at the graduate and undergraduate levels in electro-optics, 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 research in high-energy-density phenomena; 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 22 department-based professors, 58 graduate students, and 67 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 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 Ph.D. 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 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 director for appointments as research trainees.

Chemical Engineering

Professors Chen (Chair), Chimowitz (Associate Chair), Jorné, Tang, Wu
Associate Professors Yang, Yates
Assistant Professor Anthamatten
Adjunct Professors Chang *Greener
Adjunct Assistant Professor *Foster
Joint Appointments: Professors Jacobs, Harding, Rothberg, Shapir; Associate Professor King
Senior Lecturer Ebenhack
Instructor Olsen
Adjunct Instructors *M. Weinstein, *S. Weinstein
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, biochemical engineering, 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.

PH.D. PROGRAM

To educate a new generation of chemical engineers with unique interdisciplinary skills, students earning Ph.D. degrees in chemical engineering are encouraged to select thesis topics falling within materials science 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 Ph.D. 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 Ph.D. 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 Ph.D. preliminary examination as a transition from classroom to full-time research. The formal basis for admission to Ph.D. candidacy is a qualifying

* Part-time.
examination, usually taken after two years in residence, in which students defend a written proposal for thesis research. To earn a Ph.D. degree, students must complete a program of study of 90 credit hours (or 60 credit hours beyond the M.S. degree) consisting of a minimum of 30 credit hours of formal coursework (or 18 hours of formal coursework beyond the M.S. 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 Ph.D. degree requirements, which include successful defense of a dissertation presenting significant technical contributions to the field.

M.S. PROGRAM

The Master of Science degree may be obtained through either a full-time or a part-time program. Graduate students may complete a thesis (Plan A) or non-thesis (Plan B); most part-time students choose the non-thesis option (Plan B).

M.S. PROGRAM (PLAN A)

All students who pursue the M.S. degree with thesis (Plan A) are expected to earn 30 hours of credit of which a minimum of 18, 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 M.S. reading and/or research courses (CHE 491/495). Satisfactory completion of the master's thesis is also required for the degree, independent of satisfactory completion of the research courses (CHE 495).

M.S. PROGRAM (PLAN B)

All students who pursue the M.S. 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. Plan B students 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/associate chair 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 B.S.-M.S. 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 B.S.-M.S. program. This program leads to both the B.S. and the M.S. degrees in chemical engineering in five years (the B.S. at the end of the fourth year and the M.S. 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 M.S. degree. Students accepted into this program are granted a 75 percent tuition scholarship upon graduate matriculation for the remainder of their graduate program of study. They also earn a stipend in return for their teaching and research assistance.
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 M.S. 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 M.S. 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 M.S. 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, CHE 460 and 469, plus requirements mentioned on page 65 for the M.S. 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

The program for the M.S. degree should include at least one course from three of the following core areas:

- Advanced fluid dynamics/transport phenomena (e.g., CHE 441)
- Thermodynamics and statistical mechanics (e.g., CHM 455)
- Biotechnology (e.g., CHE 460, 469)
- Applied Mathematics (e.g., ME 401)

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 two additional graduate-level courses, one each from two of the core areas listed above. The chemical engineering department encourages students to develop programs of study that take advantage of the department’s special offerings in the areas of advanced materials and biotechnology.

All courses carry four credit hours unless otherwise noted.

Chemical Engineering Fundamentals

441. Advanced Fluids Dynamics
The study of the fundamental principles of fluid flow. The microscopic conservation equations are developed and represented in vector notation. Techniques for simplifying and solving well-defined, yet industrially significant problems, are presented. Time permitting, additional topics such as turbulent flow, non-Newtonian fluids, and computational fluid dynamics are included. (Fall)

454. Interfacial Engineering
Lectures on the fundamentals of interfaces, systems with high interfacial areas, and their role in modern processes and products. Topics include interfacial tension, contract angle, adsorption, surfactants, micelles, microemulsions, and colloids. (Spring)
Advanced Materials

413. Molecular Self-Assembly
This course provides an overview of several contemporary research topics pertaining to structured organic materials. Lectures focus on intermolecular interactions, the thermodynamics of self-assembly, and interfacial phenomena. Specific research topics addressed include molecular crystals, polymer crystallinity, liquid crystals, surface functionalization, self-assembled monolayers, surfactants, functional block copolymers, and biomimetic materials. Homework assignments, two exams, and a brief technical presentation or paper is required. (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)

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 spring)

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)

480. Chemistry of Advanced Materials
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 will include thin film materials, nanostructure/nanoscale/nanocomposite material. (Fall)

486. Polymer Science and Engineering
This course features the science and technology of synthetic macromolecules. Topics included 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,
Biotechnology

460. Biological System Fundamentals and Analysis
Introduction to the basics of biological system structure and function: molecules, cells, and tissues; molecular mechanisms of genetic processes; basic cell and mammalian physiology. (Fall)

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: (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. In a term project, graduate students must identify a technological need and present orally and in writing a proposal to meet that need. (Spring)

466. Microhydrodynamics
Credit—three hours
This course presents insight into the motion of small particles in a viscous fluid. Such problems are encountered in biology, biotechnology, and composite materials processing. Specific topics include flow past spheres and arbitrary bodies (thermally driven), motion of bubbles and drops, slender body theory, and leading-order inertial corrections. (Spring)

469. Biotechnology and Bioengineering
The life science and engineering principles underlying biotechnology processes are covered. The topics include microbial conversions, recombinant DNA, immune technology, and tissue cultures. Emphasis is on both life science fundamentals and process design. (Spring)

507. Advanced 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. 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. (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. Synthetic Polymer Chemistry
CHM 435. Organic Reactions
CHM 451 & 452. Quantum Chemistry I & II
ME 451. Crystallography and X-ray Diffraction
ME 452. Electron Microscopy
ECE 420. Electronic Properties of Materials
IND 407. Structure and Function of Cell Organelles
IND 408. Biochemistry
IND 410. Molecular Biology and Genetics
IND 411. Methods in Structural Biology
IND 443. Eukaryotic Genome Organization and Expression
IND 555/556. Introduction to Applied Bioinformatics and Sequence Analysis
Electrical and Computer Engineering

Professors Bocko (Chair), Fauchet, Friedman, Hsiang, Jones, Parker, Sobolewski, Titlebaum, Waag
Associate Professors Heinzelman, Mottley, Sharma
Assistant Professors Ampadu, Huang, Ignjatovic, Margala, Vosoughi, Wu
Senior Scientist and Research Professor Feldman
Adjunct and Visiting Faculty Appointments: Albonesi, Blackstock, Derefinko, Misic, Pentland, Tekalp
Joint Appointments: Professor Ning; Associate Professors Dwarkadas, Levinson; Assistant Professors Dalecki, McAleavy
Professors Emeriti Albicki, Arden, Carstensen, Kinnem, Merriam, Shapiro

The Department of Electrical and Computer Engineering offers graduate work leading to the M.S. and Ph.D. degrees. The faculty emphasizes graduate research and instruction in the general areas of electronics and computer systems, optoelectronics, silicon nanoscience, signal/image/video 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 signal processing.

For additional information on research projects and other matters please refer to the department's booklet, Graduate Studies in Electrical and Computer Engineering, which is available on request.

Applicants for graduate study are expected to have performed well in undergraduate programs leading to the B.S. 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 M.S. level as well as the needs of students who plan to pursue research at the Ph.D. 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. The research will be supervised by members of the faculty and often, though not necessarily, will form the basis for the master's thesis or doctoral dissertation.

M.S. 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 M.S. degree candidate (including those who are on their way to a Ph.D. 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, 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 bulletin or your advisor.

In addition, at least 20 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-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 M.S. exam: All Plan B (non-thesis option) full-time, part-time, and 3-2 M.S. students must pass an M.S. exam. The exam must be conducted by a committee of no less than two ECE faculty members. The committee for each exam registrant will be assigned by the Graduate Committee in Electrical and Computer Engineering. The M.S. exam committee will decide on the form of the M.S. exam for each student. The M.S. 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.”

Ph.D. students who wish to receive an M.S. degree can satisfy the M.S. exam requirement by completing Parts 1 and 2 of the Ph.D. comprehensive examination.

PH.D. PROGRAM

The Ph.D. degree requires 90 credit hours of graduate study, 60 credit hours beyond the master’s degree. Students are encouraged to begin research early in their program. The comprehensive examination, taken during the first year of study, is a requirement for continuation in the Ph.D. program.

All doctoral students must pass a Ph.D. qualifying examination and submit a satisfactory written Ph.D. thesis proposal in their third year of full-time graduate study. Students who have passed the Ph.D. 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

209. Computer Design Project
Prerequisites: ECE 200 and 202.
Senior design course for “Computer Design” concentration. Design and implementation of central-processing, memory, and input/output units.

210. Circuits for Scientists and Engineers
Prerequisites: concurrent registration in MTH 163 and PHY 122.
Circuit analysis considering passive RLC elements, ideal and controlled sources, op-amps, steady-state and transient response, transfer function, filters. Technical elective for non-ECE majors.
404. High Performance Microprocessor-Based System
Prerequisite: ECE 203/403.


405. Data and Computer Communications
Prerequisites: ECE 200 and permission of instructor.


408. Advanced Switching Theory and Design
Prerequisites: ECE 201 and permission of instructor.


II. Electronics and Solid-State

215. Integrated Circuit Systems
Prerequisite: ECE 221; open to senior majors or by permission of instructor.

Characteristics and specifications of analog integrated circuits, including operational amplifiers, voltage regulators, signal generators, active filters, phase-locked loops, analog-to-digital converters and digital-to-analog converters. Performance, measures, error budgets, and parameter design trade-offs.

216. Microprocessors and Data Conversion
Prerequisite: ECE 112, 113; open to senior majors or by permission of instructor.

Overview of the architecture of microprocessor and embedded micro-controller systems. Includes the central processing unit, memory, bus structures (internal and external, such as PCI, USB, CAN GPMB), I/O including programmable peripheral interface controllers. Timer/counters, analog-to-digital converters, digital-to-analog converters, multiplexers, and interrupt structures. The focus is on the development of applications written in a high-level programming language (C/C++). Efficient methods for designing and developing programs for embedded microcomputer systems are covered with an emphasis on processing data from peripheral devices in real-time applications. Serial and parallel I/O, interrupt applications, use of A/D and D/A converters, and applications of timer/counters are studied, with special attention given to interfacing the microcontroller to the analog world.

221. Electronic Devices and Circuits
Prerequisite: ECE 113.


222. Integrated Circuits: Design and Analysis
Prerequisite: ECE 221.

Introduction to the design and analysis of digital and analog integrated circuits. Technologies such as NMOS, CMOS, GaAs, analyzing Bipolar, and biCMOS, evaluation and interpretation of time and frequency response.

420. Physics of Solid-State Devices
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
Prerequisites: ECE 221, 230, and PHY 123.


425. Superconductivity and the Josephson Effect
Prerequisites: ECE 220, 230, or equivalent.

Introduction to superconductivity, electron tunneling, and properties of barriers between...
superconductors, including the DC and AC Josephson effects, superconducting digital and analog devices.

426. Superconducting Electronics
Prerequisites: ECE 220, 230, or equivalent.

Superconducting devices and circuits, both analog and digital. Principles and design of low power, high-speed digital integrated circuits. Generation and low-noise detection of electromagnetic radiation.

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.

461. VLSI Systems I
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 arrays structures. Design verification and testing. Design projects using computer-aided design tools: SPICE, MAGIC, IRSIUM, OCTTOOLS. Requires more advanced design projects and design aides or tools. Study of current technical literature is required.

462. VLSI Design Project
Prerequisite: ECE 261 or 222.

Senior design course for Computer Design or Integrated Electronics concentrations. 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
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.

III. Optoelectronics, Fields, and Waves

230. Electromagnetic Waves
Prerequisites: MTH 163, 164, PHY 122, ECE 113.


431. Microwaves and Wireless
Prerequisite: ECE 230 or permission of instructor.

Generation, transmission, control, and detection of electromagnetic waves. Antennas, cavities, couplers. Path loss, multipath, modulation techniques, coding.

434. Transducers and Actuators
Prerequisites: MTH 163, 164, PHY 122, ECE 113, 230.

Static and quasistatic field for microelectromechanical transducers. Lumped parameter electromechanics and two-port descriptions. Reciprocity, sensitivity, and noise considerations. Review of fabrication technologies. Case studies of practical micro-actuators and sensor elements. Laboratory.
435. Introduction to Optoelectronics  
Prerequisites: ECE 221, 230, or equivalent/permission of instructor.

Introduction to the fundamentals of wave propagation in materials, waveguides and fibers, generation, modulation and detection of light using semiconductor devices, and elements of optocommunication systems.

437. Wireless Telecommunication  
Prerequisites: ECE 241, 230 or permission of instructor.

Cellular telephone system design and performance are traded against limited RF bandwidth and low cost. Modern digital systems with very high capacity are exemplified by an in-depth examination of Code Division Multiple Access (CDMA).

492. Special Topics: Physics of Advanced Optoelectronic and Electronic Devices  
Prerequisites: elements of solid-state physics (at the level of Kittel) and quantum mechanics (senior undergraduate course); or permission of instructor.

The purpose of the course is to introduce students to current research and issues in nanostructured semiconductor materials. These materials are of great interest from a fundamental point of view (new electronic and optical properties) and because they may be used in future high-performance optoelectronic devices. Topics covered include (1) a survey of the electronic and optical properties of semiconductors; (2) semiconductor quantum wells, wires, and dots: manufacture, electronic and optical properties; (3) electronic transport in nanostructures; (4) other properties (mechanical, thermal, chemical, etc.); (5) present and future device applications of semiconductor quantum structures.


Nano-science (giving nanometer-size objects properties their constituent material does not have in nature) and nanotechnology (the use of these objects to perform useful functions in devices) allow scientists and engineers to routinely do what was long thought to be impossible. The purposes of this course are to provide an introduction to the scientific foundations of nanoscience and the materials science that makes it possible, and to focus on developments in three major domains of applications, electronics, photonics, and biosensing. Graduate students from all the engineering departments, physics, and chemistry should find this course of interest. Graduate students from other departments or qualified undergraduate students may enroll with permission of the instructor.

IV. Signals and Communications

241. Signals  
Prerequisites: MTH 164 and 113.

Introduction to discrete and continuous time signal theory and analysis of linear time-invariant systems. Signal representations, convolution, Fourier analysis, filtering of continuous and discrete time signals, Laplace and Z-transforms. Laboratory.

242. Communications  
Prerequisite: ECE 241.

Analog and digital modulation and demodulation theory. Introduction to probability theory and stochastic processes, statistical characterization of noise and communication channels. Performance of communication systems in the presence of noise. Laboratory.

437. Wireless Telecommunication  
Prerequisites: ECE 241, 230 or permission of instructor.

Cellular telephone system design and performance are traded against limited RF bandwidth and low cost. Modern digital systems with very high capacity are exemplified by an in-depth examination of Code Division Multiple Access (CDMA).

440. Introduction to Random Processes  
Prerequisites: ECE 241 and ECE 242.


441. Detection and Estimation Theory  
Prerequisite: ECE 440 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 linear unbiased estimators, least squares estimation, applications to detection of signals in noise and estimation of signal parameters.

444. Digital Communications  
Prerequisite: ECE 242

Digital communication system elements, source coding, measures of information, characterization and representation of communication
systems. Modulation and demodulation, orthogonal and bi-orthogonal signaling schemes, synchronization, multiple access. Introduction to spread spectrum techniques and mobile communications. Optimum detectors, performance analysis of digital communication systems. Channel coding and error correction codes.

446. Digital Signal Processing
Prerequisites: ECE 242.

Review of discrete-time signals and systems, discrete Fourier transform, FFT algorithms, windows and classical spectral analysis, circular convolutions, multi-rate signal processing.

447. Image Processing
Prerequisites: ECE 242 recommended, ECE 440, 446.


448. Pattern Recognition
Prerequisites: ECE 241, 242, 447, or permission of instructor.

Statistical decision procedures, hypothesis testing, linear and quadratic classifiers, clustering, feature extraction and nonlinear mapping, parameter estimation techniques, neural nets, wavelets applications from image recognition and image understanding.

449. Digital Video Processing
Prerequisite: ECE 447 or permission of instructor.

Basics of digital video filtering, compression and content description. Topics include algorithms for 2-D and 3-D motion estimation, video segmentation, object tracking, frame rate conversion, deinterlacing, image enhancement, image and video compression techniques, entropy coding, transform and subband/wavelet coding, object-based coding, and international standards for image and video compression and content description. Applications to interactive digital TV, interactive Web multimedia, and image communication.

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. Special Topics

477. Reduction and Analysis of Noisy Data
Prerequisite: MTH 162.

Basic ideas of sampling, statistics, inference, and deduction from noisy data. Properties of various distributions, testing of hypotheses, statistical inference, analysis of variance, regression analysis and curve fitting, and nonparametric statistics, using problems and examples drawn from areas of interest. Emphasis on appropriate use of statistical measures in reporting and drawing conclusions from data.

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 call the electrical and computer engineering office at (585) 275-4054.

493. Master's Essay

Supervised preparation of the master's essay for Plan B candidates.

495. Research in Electrical and Computer Engineering (M.S.)
Credit to be arranged

496. Special Projects Course in Electrical and Computer Engineering (M.S.)
Credit to be arranged

591. Reading Course in Electrical and Computer Engineering (Ph.D.)
Credit to be arranged

Supervised reading on topics beyond those available in existing courses or on specialized topics.

595. Research in Electrical and Computer Engineering (Ph.D.)
Credit to be arranged
Materials Science

Professors Bocko, Burns, Chen, Chimowitz, Dinnocenzo, Fauchet, Funkenbusch, Gao, Hsiang, Jacobs, Jones, Jorné, Lambropoulos (Director), Li, Quesnel, Rothberg, Shapir, Sobolewski, Wicks, J. H. D. Wu
Assistant Professors M. Anthamatten, H. Yang, M. Z. Yates

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 M.S. and Ph.D. degrees. The program draws students from a wide range of educational background: chemical, electrical, and mechanical engineering, materials science, ceramics, chemistry, physics, and optics. It is strongly recommended that applicants take the GRE. The TOEFL 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 Department of Chemical Engineering, a materials science student can work on the synthesis, processing, and molecular simulation of advanced materials for aerospace, biomedical, information, energy, and environmental applications. 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; 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; film preparation via chemical vapor deposition; 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 scratching of polymer films, 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, 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, bulk diffusion effects in semiconductors, ultrafast electronics, and high-temperature superconductors in thin films. Current projects include superconducting and magnetic thin films, microwaves, picosecond phenomena, fluctuations in superconductors, and bioelectric properties.
In The Institute of Optics, a materials science student concentrates on the properties of materials important to optical applications. 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.

**Ph.D. Program**

A typical program for a materials science (MSC) Ph.D. student entering with a B.S. 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 Ph.D. student entering with an M.S. 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.

**M.S. Program**

The M.S. degree in materials science requires a minimum of 30 credit hours of graduate courses. For students electing to obtain the M.S. 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. For students electing to obtain the M.S. 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, and students must complete a research project, often in the form of a research course.

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: MTH 163, 164; PHY 123.*

Relationship between microstructures of solid materials and their engineering properties. The dependence of mechanical, electronic, magnetic, thermal, and chemical properties of metals, semiconductors, ceramics, polymers, and glasses on their chemical bonding, electronic structure, atomic arrangement, and phase composition.

210. Electronic Properties of Materials
(Same as ECE 220)
*Prerequisites: PHY 123, MTH 164.*

401. Phase Transformations
(Same as ME 408)
Prerequisite: ME 460.

The physical, chemical, and mechanical properties of metals and alloys can be varied drastically by thermal and mechanical treatments which change their microstructure. This course is concerned with an atomic level description of these changes, including the importance of crystallography, kinetics, and structural defects.

403. Crystallography and X-Ray Diffraction
(Same as ME 451)
Prerequisite: permission of instructor.

Crystallography, symmetry elements, space groups, X-ray diffraction, single crystal diffraction, powder patterns, Fourier transforms, Patterson functions, grain size effects, residual stress and cold work, diffuse and small angle scattering, Bragg and Laue, X-ray topography. Weekly laboratory.

404. Electron Microscopy
(Same as ME 452)
Prerequisites: MSC 403 and permission of instructor.

Microstructural features and their effects on mechanical, electrical, chemical, 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.

405. Thermodynamics of Solid Materials
(Same as ME 460)
Prerequisite: ME 123 or CHE 225.

Review of basic thermodynamic quantities and laws; phase transformations and chemical reactions; partial molal and excess quantities; phases of variable composition; free energy of binary systems; surfaces and interfaces; diffusion. Emphasis is on the physical chemistry of the solids.

406. Fracture and Adhesion
(Same as ME 461)
Prerequisites: ME 280, 226, and 442.

Linear elastic fracture mechanics. Griffith theory. K and J approaches to toughness measurements. Adhesion. Crack nucleation and fatigue crack growth. Failure analysis. Emphasis on the role of microstructure in determining fatigue and fracture behavior. Fracture-tough materials. This is an advanced course taught at or near the level of current research.

407. Experimental Materials Science
(Same as ME 462)
Prerequisite: permission of instructor.

Design, planning, execution, and reporting of three or four intensive laboratory projects involving heat treatment, mechanical testing, quantitative metallography, etc. Emphasis is on the interaction between mechanical behavior of materials and their internal microstructure. Cross-listed as ME 242, but requires significant extra work.

408. Microstructure and Properties
(Same as ME 463)
Prerequisite: ME 280.


409. Mechanical Behavior of Solid Materials
(Same as ME 481)
Prerequisites: ME 280, ME/MTH 163.


410. Mechanical Properties of Polymers
(Same as ME 411)

Structure of polymers, elastic behavior, finite strain elasticity, visco-elastic behavior of polymers, time-temperature superposition, free volume theory, relaxation processes, nonlinear and anisotropic behavior, yielding, and fracture.

420. Electronic Properties of Materials
(Same as ECE 420)
Prerequisite: ECE 221 or equivalent.

Elements of solid-state theory. Topics include crystal lattices, lattice vibrations and phonons, energy band theory, semiconductor crystals, donor-acceptor statistics and electron transport in semiconductors, collective phenomena.

422. Superconductivity and the Josephson Effect
(Same as ECE 425)
Prerequisites: ECE 220, ECE 230 or equivalent.

Introduction to superconductivity, electron tunneling, and properties of barriers between superconductors, including the DC and AC Josephson effects.
423. Electromechanics of Particles
(Same as ECE 436)
Prerequisite: ECE 230 (and permission of instructor if undergraduate).

Description and development of models for the forces, torques, and electrohydrodynamics of particles, droplets, and bubbles in electric and magnetic fields.

425. Bioelectric Phenomena
(Same as ECE 450, BME 450)
Prerequisite: permission of instructor.

A study of the passive and active dielectric properties of biological materials, including macromolecular solutions, membranes, cells, and tissues. Physical and biological effects of electric fields, including diagnostic and therapeutic uses and biological hazards of electric fields and electromagnetic radiation. Effects of low frequency magnetic fields.

426. Semiconductor Devices
(Same as ECE 423)


431. Chemistry of Advanced Materials
(Same as CHE 480)

The preparation, structure, composition, and properties of advanced materials is covered with emphasis on the underlying chemistry. Atomic structure and bonding of crystalline and amorphous solids and crystalline defects are discussed. One central theme is materials synthesis and processing by chemical and physical deposition methods. The course also focuses on the relation of structure to properties of materials. Selected topics to illustrate the basic concepts and principles include thin film materials, nanostructured/nanoscale/nanocomposite materials, and bulk materials.

432. Liquid Crystalline Polymers
(Same as CHE 483)
Prerequisite: CHE 286 or equivalent.

Materials chemistry and physics. Theoretical treatment and experimental measurement of various modes of molecular order underlying liquid crystallinity; field-induced phenomena of liquid crystalline fluids; statistical mechanics of semirigid liquid crystalline polymers. Rheology and processing of liquid crystalline polymers as lightweight, high-strength materials. Applications to electro-optics, optics, photonics, and optoelectronics.

433. Polymer Science and Engineering
(Same as CHE 486)

Mechanism and kinetics of polymerization; polymerization processes in bulk, solution, suspension, and emulsion. Spectroscopy and characterization of chain structures; molecular weight distribution and averages by membrane osmometry, viscometry, and light scattering and gel permeation chromatography. Thermodynamics of polymer solutions and blends. Polymer morphology, mechanical and rheological properties. Industrial and high-tech applications.

434. Polymer Rheology and Processing
(Same as CHE 487)
Prerequisites: CHE 496, CHM 421, or permission of instructor.

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 state, and the study of fabricating operations, such as calendaring, extrusion, and injection molding.

437. Electroactive and Nonlinear Optical Polymers
(Same as CHE 484)

The diverse electroactive properties of polymers are examined: semiconductivity, metallic conductivity, photoconductivity, superconductivity, nonlinear optical effects, piezoelectric effects, and ionic conductivity. Molecular and morphological origins of the electroactive properties of polymers. Synthesis, characterization, processing, and applications of electroactive polymers.

438. Processing of Microelectronic Devices
(Same as CHE 482, CHE 282)

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.

439. Biological System Fundamentals and Analysis
(Same as CHE 460)

Introduction to the basics of biological system structure and function: molecules, cells, and tissues; molecular mechanisms of genetic processes; basic cell and mammalian
physiology emphasizing membrane, respiration, cardiovascular, and renal systems; applications of kinetic analysis and transport phenomena to biological systems.

461. Introduction to Polymer Chemistry
(Same as CHM 421)
Prerequisites: organic chemistry and physical chemistry or equivalent.

Introduction to the chemistry of macromolecules. The course focuses on the general synthetic schemes for preparing polymers, their characterization, and general aspects of structure/property relations in polymers.

463. Synthetic Polymer Chemistry
(Same as CHM 424)
Prerequisite: CHE 486 or CHM 421.

The fundamentals of synthesizing high polymers from monomers is the major focus of this course. Advances and new concepts in polymer synthesis are covered. Industrially important polymers are considered in terms of polymer design synthesis and properties.

470. Optical Properties of Semiconductors
(Same as OPT 421)

The course concerns the aspects of the solid-state physics of semiconductors which influence their optical properties. The physics of optical absorption, emission, reflection, modulation, and scattering of light is covered. III-V semiconductors are emphasized, elemental and II-V semiconductors are covered in less detail. The optical properties of reduced dimensionality structures such as quantum wells are contrasted with those of bulk semiconductors.

471. Optical Fabrication and Testing
(Same as OPT 443)

This laboratory/lecture course gives a first-hand working knowledge of optical glasses, glass mechanical and optical properties, optical component specs, manufacture, and testing. Topics include loose abrasive grinding, pitch polishing, CNC ring tool generating, magnetorheological finishing. Students make lenses, prisms, and colored filter glasses.

473. Introduction to Optoelectronics
(Same as ECE 435)

Graduate-level course for ECE 235. Introduction to the fundamentals of wave propagation in materials; waveguides and fibers; generation, modulation and detection of light using semiconductor devices; and elements of optocommunication systems.

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.

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

550. Solid-State Physics I
(Same as PHY 521)
Prerequisites: PHY 407, 408, 420, 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.

551. Solid-State Physics II
(Same as PHY 522)
Prerequisite: PHY 521.

Electron-phonon interaction, transport, magnetism, and topics of current interest such as superconductivity or localization, to be determined by the instructor.

552. Special Topics in Materials Science
(Same as PHY 524)

Subject matter to be selected by the instructor from among topics of current interest in materials science.

591. Ph.D. 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. Ph.D. Research in Materials Science
Mechanical Engineering

Professors Betti, Burns (Chair), Clark, Funkenbusch, Gans, *Genberg, Gracewski, Lambropoulos, Li, McCrory, Meyerhofer, Perucchio, Quesnel, Thomas
Assistant Professor Ren
Adjunct Professors Becene, Zhu
Adjunct Assistant Professors *Goncharov, *Maximov
Joint Appointments: Professor Waugh; Associate Professor Lerner
Lecturers *Gao, *Kleckner, *Ronald
Professors Emeritus Goldman, Simon

The Department of Mechanical Engineering offers graduate work leading to both the M.S. and Ph.D. 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 (TOEFL) 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 Center for Optics Manufacturing (COM), 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) and Biomedical Engineering (BME) 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; 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

* Part-time
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.

**PH.D. PROGRAM**

The Ph.D. degree requires 90 semester hours of graduate credit. A typical program includes about 40 to 60 hours of coursework, with the remaining hours in Ph.D. research. Candidates are required to take at least 32 hours of coursework at the 400 level or higher, of which at least 24 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 Ph.D. program.

Students who pass the preliminary exam and faculty evaluation are expected to take an oral Ph.D. 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 Ph.D. 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.

**M.S. PROGRAM**

The M.S. degree requires 30 semester hours of graduate credit. For candidates in Plan A, 6 to 12 hours of the 30 required will be for M.S. 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 M.S. studies. Those candidates for the M.S. degree under Plan B who do not intend to continue on for a Ph.D. 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 M.S. 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 M.S. degree in mechanical engineering will normally take a program which emphasizes courses in the various energy and mechanics areas. Those seeking an M.S. 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 173).

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.
201. Applied Boundary-Value Problems  
Prerequisites: ME/MTH 163 and 164.

202. Engineering Analysis: Complex Variables  
Prerequisites: ME/MTH 163 and 164.

203. Kinematics of Machinery  
Prerequisites: ME 120 and 121.

204. Mechanical Design  
Prerequisite: ME 226, ME 211 recommended.

205. Advanced Mechanical Design  
Prerequisite: ME 204.

211. Computational Methods in Mechanical Engineering  
Prerequisites: ME/MTH 163, 164.

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.

224. Advanced Heat Transfer  
Prerequisite: ME 223.

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.

227. Applied Fluid Dynamics  
Prerequisite: ME 225.

241. Fluid Dynamics and Thermal Sciences Laboratory  
Prerequisite: ME 225.

242. Materials and Solids Laboratory  
Prerequisites: ME 121, 226, 241, 280.

250. Optimum Design  
Prerequisites: ME 226, ME 204 (or equivalent), and some programming experience.

251. Heat Power Applications  
Prerequisites: ME 123 and 225 (may be taken concurrently).

253. Nuclear Engineering  
Prerequisites: PHY 123, ME 123.

280. Introduction to Materials Science  
Prerequisites: ME/MTH 163 and 164; PHY 123.

281. Mechanical Properties of Materials

400. Graduate Research Seminar  
No credit  
Introduction to active research programs in the department.

401. Methods of Applied Mathematics  
Prerequisites: 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  
Prerequisites: 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. Perturbation and Asymptotic Analysis  
Prerequisite: MTH 282.  
Dimensional analysis; asymptotic expansions; asymptotic techniques applied to integrals and solutions to ordinary and partial differential equations; regular and singular perturbation; boundary layer theory; turning point analysis and WKB theory; geometrical optics; applications to fluid mechanics and wave propagation.

405. Diffusion  
Prerequisites: ME 201 or MTH 281.  
Length and time scales in diffusion; analytical, numerical, and asymptotic methods. Applications selected from the following: diffusion of magnetic fields; chemically reacting systems; moving systems; diffusion and waves; diffusion in solids; free boundary problems; radiation transfer in gases; kinetic theory; random walks and diffusion.
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; 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, visco-elastic behavior of polymers, time-temperature superposition, free volume theory, relaxation processes, nonlinear and anisotropic behavior, yielding and fracture.

421. Physical Rheology  
Prerequisite: permission of the instructor.


424. Introduction to Robust Design and Quality Engineering  
(Same as ME 222)  
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.

428. Geophysical Fluid Dynamics  
Prerequisites: ME 201, 225 and MTH 281.

The theory of fluid motions in oceans and atmospheres. Topics: static structure; the Boussinesq approximation; internal gravity waves; waves in a compressible, stratified fluid; geostrophic flow; inertial waves in a rotating fluid; spin-down processes; Rossby waves; laminar and turbulent convection; interaction of convection and rotation.

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, micro-instabilities, drift instability, non-linear 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)  
Prerequisite: 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.

442. Introduction to Dislocations and Disclinations  
Prerequisite: ME 226, 280.


443. Mechanical 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 loading 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.

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. Experimental Materials Science
Prerequisite: permission of instructor.

Design, planning, execution, and reporting of laboratory experiments, including both existing experiments and a significant independent research project. Cross-listed as ME 242, but requires significant extra work.

463. Microstructure
Prerequisite: ME 280.


465. Laser Systems
(Same as OPT 465)
Prerequisites: OPT 441, 442 or equivalent, and OPT 461, 462 or equivalent (may be taken concurrently).

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.

471. Geometric Modeling and Engineering Graphics

Modeling and representation of solid objects and automated engineering graphics. A theory based on geometry, set theory, and topology is developed to model and represent rigid solids. Useful algorithms which operate on the representations are studied.

481. Mechanical Behavior of Solid Materials
Prerequisites: ME 280, ME/MTH 163, ME 226.


482. Biofluid Mechanics
Prerequisite: ME 225.

Blood; heart; arterial flow; microcirculation; venous flow; blood flow in lungs. Transcapillary exchange (particularly oxygen); compartment models. Air flow in lungs. Thermal regulation in physiology. Life at low Reynolds numbers.

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.

484. Topics in Microcirculation I
(Same as BPH 440)

An examination of microcirculatory systems and the transport phenomena which occur there. Included in the topics studied are network architecture (changes with age, pathological conditions, models); hemodynamics (roles of blood cell deformabilities, aggregation, cytocris); blood flow-metabolism coupling (control); and oxygen transport.

485. Cellular Mechanics and Transport
(Same as BPH 441)

Part I—Equations of membrane equilibrium including bending, biological membrane elasticity in shear and area dilation, membrane curvature, thermal tensions in membranes,
analysis of axisymmetric deformations of lamellar structures, white blood cell mechanics. Part II—Mass transport and diffusion in biological tissue, especially the interstitium.

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 student in general makes a thorough search and study of the literature dealing with the current research in a given field.

493. Master’s Essay
Supervised preparation of the master’s essay for Plan B candidates.

495. Research in Mechanical Engineering
Credit to be arranged

531. Nonlinear Dispersive Waves
Prerequisite: ME 402 or permission of instructor.
Several aspects of nonlinear wave physics are studied. Specific physical applications include surface waves on water, high intensity laser beams in nonlinear media, and stimulated Raman scattering in plasma.

532. Magnetohydrodynamics

534. Plasma Stability
Prerequisite: ME 434 or permission of instructor.
Stability of magnetically confined plasma, δW formalism, double adiabatic equation, comparison theorem, shear stabilization, minimum-β fields, resistive instabilities. Tokamak and Mirror stability theory.

535. Laser-Plasma Interactions
Prerequisite: ME 434 or permission of instructor.

536. Hydrodynamic Stability and Turbulence

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
The Institute of Optics

Professors Agrawal, Boyd, Fienup, George, Knox (Director), Moore, Stroud, Teegarden, Wicks (Associate Director)
Associate Professors Bergers, Brown, Novotny, Zavislan
Assistant Professors Alonso, Guo
Adjunct Professor Walmsley
Adjunct Assistant Professors Bentley, Buralli, Marciante
Joint Appointments: Professors Bigelow, Eberly, Fauchet, Foster, Jacobs, Williams, Wolf;
Associate Professor Seka; Lecturer Oliver
Senior Scientist Lukishova
Professors Emeriti Givens, Hopkins, Thompson

The Institute of Optics is devoted to teaching and research in optics and optical engineering. It offers programs leading to B.S., M.S., and Ph.D. 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, ultra-high 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 B.S. 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.

PH.D. PROGRAM

It is expected that a student completing this program in optics will be ready to assume a role as an independent researcher 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 student 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 student to devote full time to coursework. Four courses are taken each semester. The purpose of the first year's work is to provide a broad background in optical physics and engineering. Courses include Mathematical Methods for Optics, OPT 411; Geometrical and Instrumental Optics, OPT 441, 442; Optical Radiation and Detectors, OPT 425; Physical Optics, OPT 461, 462; and Quantum Mechanics for Optics, OPT 412. At the beginning of their second year of residence students take a written preliminary examination which covers the content of the first year of graduate study plus additional topics. In the following 15 months, students prepare a written thesis proposal which forms the basis for the oral qualifying examination. In the second year of residence, the student takes courses in advanced subjects and concentrates in some area of specialty in preparation for Ph.D. research. The student is required to take not less than 16 hours of courses during this year. At least eight hours of these courses should be at the 500 level.

During the second year, students usually fulfill their teaching requirement, which is two semesters of service. This service is required whether or not the student has received financial support from the University.
The remainder of the Ph.D. program is spent in advanced coursework and research, culminating in the writing and defense of a Ph.D. thesis. The Ph.D. program is normally completed in four to six years.

M.S. PROGRAM

The master's degree program is designed to provide the student who has 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 M.S. in optics is available to both full-time and part-time students. As outlined under general University regulations in this bulletin, the optics M.S. can be pursued under either Plan A or B. There is a required set of core courses common to all options within the M.S. 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 course, thesis research and written M.S. thesis, and successful final defense of the M.S. thesis. Credit for the thesis may not be less than 6 nor more than 12 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 to reach a total of 30 semester hours, one additional course in geometrical optics, 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.

B.S.-M.S. PROGRAM

Undergraduate juniors majoring in optics may apply for admission into a five-year program leading to both a B.S. and an M.S. degree in optics. Students learn of acceptance into this program in the spring of their junior year and can begin master's-level independent work during the senior year. The student must meet all of the requirements for the B.S. degree as well as those for the M.S. 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**

<table>
<thead>
<tr>
<th>Course</th>
<th>Course</th>
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<tbody>
<tr>
<td>OPT 461 or 441</td>
<td>OPT 462 or 442</td>
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<tr>
<td>OPT 425</td>
<td>OPT 256</td>
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<tr>
<td>OPT 223</td>
<td>OPT 224</td>
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<tr>
<td>Elective</td>
<td>Elective</td>
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</tbody>
</table>

The normal fifth-year program should follow that for the master's student Plan A or Plan B. However, the student in the B.S.-M.S. 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

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Code</th>
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<tbody>
<tr>
<td>OPT 425</td>
<td>OPT 442</td>
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<td>OPT 441</td>
<td>OPT 462</td>
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<tr>
<td>OPT 461</td>
<td>OPT 465</td>
</tr>
<tr>
<td>Elective</td>
<td>Elective</td>
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B.S.-M.S. students following a Plan B program will satisfy the regular requirements for the B.S. degree as well as those for the M.S. 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 M.S. candidates for financial aid in the fifth year.

M.S. 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 the student to participate in the work block of the program, he or she 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 non-disclosure agreements, etc.). During the work block, the student will be paid wages comparable to those of other employees with similar educational backgrounds and experience.

During the time the student is employed in industry, he or she will be registered for a special co-op program and will have all of the normal rights and privileges of a matriculated student, even though he or she is 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 M.S. 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 M.S. 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
**Prerequisites:** OPT 242 and 261.

Intensive laboratory course, with experiments on optical imaging systems, diffraction, interference, holography, lasers, detectors, spectroscopic instruments, and optical communications systems.

411. Mathematical Methods for Optics
**Prerequisites:** ME 201, 202 or equivalent, and permission of instructor.

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.

412. Quantum Mechanics for Optics
**Prerequisite:** one course in undergraduate wave mechanics or permission of instructor.

A rigorous development of the foundations of quantum theory in terms of the abstract Hilbert space approach, and an application of this formalism to problems of interest in quantum optics and radiation theory.
421. Optical Properties of Semiconductors

The course concerns the aspects of the solid state physics of semiconductors which influence their optical properties. The physics of optical absorption, emission, reflection, modulation, and scattering of light is covered. III-V semiconductors are emphasized, elemental and II-VI semiconductors are covered in less detail. The optical properties of reduced dimensionality structures such as quantum wells are contrasted with those of bulk semiconductors.

425. Radiation and Detectors

Generation, detection, and measurement of optical radiation, including cavity radiation, emissivity, pyrometry, radiometric measurements, detectors of radiation, sources of noise in detectors, and imaging systems.

428. Optical Communications

The course is designed to give the student a basic understanding of the optical communication systems while making him or her aware of the recent technological advances. The following topics are covered: components of an optical communication system, propagation characteristics of optical fibers, light wave sources such as light-emitting diodes and semiconductor lasers, optical receivers, noise analysis and bit error rate, coherent communication systems, multichannel communication systems, solution-based communication systems.

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, ray tracing, and first-order properties of systems; magnification, F/number, and numerical aperture; stops and pupils, telecentricity vignetting; telescopes, microscopes, magnifiers, and projection systems; the Delano diagram; the eye and visual systems, field lenses; optical glasses, the chromatic aberrations, and their correction; derivation of the monochromatic wavefront 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; and field flatteners.

442. Instrumental Optics

Prerequisite: OPT 441.


443. Optical Fabrication and Testing

A lecture and laboratory experience that studies optical glass and the most modern methods for manufacturing and evaluating precision optics. Laboratory taught by a master optician exposes students to classical loose abrasive grinding, pitch polishing, and optical metrology tools used for measuring surface figure and micro roughness.

444. Lens Design

Prerequisite: OPT 444.


448. Principles of Eye Design

This course explores the design of the human eye, revealing the optical and neural factors that limit color and spatial vision. The design of eyes (such as those of predatory birds and the compound eyes of insects) that evolved to operate in environments different from that of the human eye are examined. The course begins with a treatment of the information losses associated with the eye’s optics, the photoreceptor mosaic, and the ganglion cell array that transmits visual information to the brain. The course ends with a discussion of image processing by the visual cortex of the brain.
189. Instrumentation and Methods for Vision Research
(Same as CVS 449 and BCS 449)
This course describes the design, construction, and operation of optical instrumentation used in modern vision research. We discuss various techniques for delivering stimuli to the retina including maxwellian view optics and CRT displays. 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 such as optical coherence tomography, monitoring eye position such as Purkinje eye tracking, and monitoring the brain such as with infrared reflectance imaging.

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.

461. Physical Optics I
Prerequisites: Undergraduate electromagnetic theory, advanced calculus, vector analysis.
Principles of physical optics, including diffraction and propagation based on Fourier transform theory; Fresnel and Fraunhofer diffraction; Fourier transforming and imaging properties of lenses; frequency analysis of optical systems; partial coherence.

462. Physical Optics II
Prerequisites: Undergraduate electromagnetic theory, advanced calculus, 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 includes 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; optical waveguides.

463. 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.

465. Laser Systems
Prerequisites: undergraduate electromagnetic theory and quantum mechanics.
This course provides an up-to-date knowledge of modern laser systems. Topics covered include laser resonators and their modes, ABCD law of Gaussian beams, cavity design, two-level atomic systems, gain spectrum, homogenous and inhomogenous broadening, pumping schemes, rate equations, tuning and spectral control, Q switching, mode-locking, various gas, liquid, and solid-state lasers.

467. Nonlinear Optics
Prerequisites: open to any graduate student or to undergraduates who have taken OPT 261, 262, 224, and 225.
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.

476. Biomedical Optics
Prerequisite: basic knowledge of quantum mechanics, statistical mechanics, linear algebra, and different equations; open to graduate students and upper-level undergraduates (with permission of the instructor).
Major topics are biomedical spectroscopy (absorption, fluorescence, Raman, and elastic scattering) propagation of photons in highly scattering media (such as tissue) techniques for high-resolution imaging in biological media: confocal imaging, multiphoton imaging, and optical coherence tomography.

481. Technical Entrepreneurship
The course provides an opportunity to examine the management practices associated with innovation and new business development. The analysis of entrepreneurship is evaluated from the perspective of start-up ventures and established companies. There is an appraisal of the similarities and differences in the skills and the functions required to develop successful projects in both types of situations. A range of manage-
ment issues is discussed, including organizational development, analysis of market opportunities, financial planning and control, capitalization, sources of funds, the due-diligence process, and valuing the venture.

491. Reading Course in Optics (M.S.)
Credit to be arranged
Supervised reading and study on topics beyond those covered in existing formal courses.

492. 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.

493. Master's Essay
Supervised preparation of a master's essay for Plan B candidates.

495. Research in Optics (M.S.)
Credit to be arranged

521. Optical Interactions in Solids
The 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 fifteen-minute overview of a specific experimental technique, or device which 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 Communications
Prerequisites: OPT 461; OPT 428 recommended (but not required).

The course is designed to provide the student understanding of the recent advances in the field of lightwave technology. The following topics are covered: dispersive and nonlinear effects in optical fibers; linear and nonlinear properties of fiber Bragg gratings; linear and nonlinear properties of fiber couplers, 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.

551. Introduction to Quantum Optics
Prerequisite: OPT 412 or PHY 407/408 or permission of instructor.

Introduction to quantum and semiclassical radiation theory. Topics covered include interaction of atomic systems with resonant optical fields, pulse propagation, relation between quantum and semiclassical radiation theories, spontaneous emission, and resonance fluorescence.

552. Quantum Optics I
Prerequisite: OPT 551 or permission of instructor.

Continuation of OPT 551, with emphasis on advanced special topics in laser spectroscopy, such as quantum radiation theory, density matrix techniques, superradiance, stimulated Raman scattering, atomic collisions, and resonance fluorescence.

553. Quantum Optics II
Prerequisite: OPT 551 or PHY 531.

Quantum properties of the free electromagnetic field; coherent states and quantum coherence theory; quantum correlation functions; thermal radiation; photon statistics of quantum fields; interaction of radiation with atoms and charges; photodetection; two-level atoms; and laser theory.

563. Statistical Optics
Prerequisites: OPT 461 and 462; students are encouraged to take PHY 404 concurrently.


564. Theory of Optoelectronic Systems
Prerequisite: OPT 461.

An advanced course in physical optics and communications with topics in major areas that are important to an understanding of the performance of modern optoelectronic systems. Topics treated include scattering, optical information processing, speckle and laser radar, automatic pattern recognition, and remote sensing.

567. Advanced Nonlinear Optics
A selection of special topics from the field of nonlinear optics, including the origin of optical nonlinearities, local field effects, self focusing
and spatial solutions, polarizations effects, chaos and instabilities, quantum statistical aspects of nonlinear optics, and device applications.

568. Waveguide Optoelectronic Devices

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.

591. Reading Course in Optics (Ph.D.)
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 nanometer 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.

592. Modern Coherence Theory


595. Research in Optics (Ph.D.)
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.
Eastman School of Music

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Donna Brink Fox, Ph.D. . . . Interim Senior Associate Dean of Academic Affairs
Marie Rolf, Ph.D. . . . Associate Dean of Graduate Studies

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THE DEGREE MASTER OF ARTS
Candidates who matriculate for the Master of Arts degree may major in music composition, music education, musicology, music theory, or music theory pedagogy. The program of study in music education requires a written thesis or a field project, and candidates are expected to show marked ability in research. 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 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, jazz studies and contemporary media, conducting (choral), and piano accompanying and chamber music. Supplementing the prescribed coursework, the majors in performance and literature and jazz studies and contemporary media 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 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 a limited number of hours of credit 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.

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The degree Doctor of Musical Arts (D.M.A.) 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, music education, composition, conducting, or piano accompanying and chamber music. In addition to the prescribed series of courses, requirements include the preparation of an acceptable dissertation or one or more documents and several public demonstrations of practical musicianship. 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.

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Nancy Chin, Ph.D. (Rochester) . . . Assistant Professor of Community and Preventive Medicine
* Lynne Davidson, Ph.D. (Rochester) . . . Assistant Professor of Community and Preventive Medicine
Mark Davies, M.D. (Trinity College) . . . Assistant Professor of Surgery
Barbara J. Davis, Ph.D. (SUNY, Upstate) . . . Assistant Professor of Neurobiology and Anatomy
Ann Dozier, Ph.D. (Rochester) . . . Assistant Professor of Community and Preventive Medicine
Diana Fernandez, M.D. (Minnesota) . . . Assistant Professor of Community and Preventive Medicine
Deborah Fowell, Ph.D. (Oxford) . . . Assistant Professor of Microbiology and Immunology in the Center for Vaccine Biology and Immunology
Edward G. Freedman, Ph.D. (Pennsylvania) . . . Assistant Professor of Neurobiology and Anatomy
Lin Gan, Ph.D. (Texas, Houston) . . . Assistant Professor of Neurobiology and Anatomy in the Center for Aging and Developmental Biology and of Ophthalmology
Greg Gdowski, Ph.D. (Boston) . . . Assistant Professor of Neurobiology and Anatomy
Roman Giger, Ph.D. (Zurich) . . . Assistant Professor of Neurology
Wolfgang Haas, Ph.D. (Albany Medical College) . . . Assistant Professor of Microbiology and Immunology in the Center for Oral Biology
Susan H. Horwitz, Ph.D. (Union Institute) . . . Assistant Professor of Psychiatry
Wei Hsu, Ph.D. (Mount Sinai) . . . Assistant Professor of Biomedical Genetics in the Center for Oral Biology and of Dentistry
Jiaoti Huang, M.D. (Anhui Medical) . . . Assistant Professor of Pathology and Laboratory Medicine
Li-Shan Huang, Ph.D. (North Carolina) . . . Assistant Professor of Biostatistics
Xia Jin, M.D. (Peiping Union Medical College) . . . Assistant Professor of Medicine
Paul J. Kammermeier, Ph.D. (Case Western Reserve) . . . Assistant Professor of Pharmacology and Physiology
David R. Kornack, Ph.D. (Cornell) . . . Assistant Professor of Neurobiology and Anatomy
Nancy S. Krieger, Ph.D. (Stanford) . . . Assistant Professor of Medicine and of Pharmacology and Physiology
* Jill Lavigne, Ph.D. (Rochester) . . . Assistant Professor of Community and Preventive Medicine
Yi Fen Lee, Ph.D. (Wisconsin) . . . Assistant Professor of Urology
Willis Li, Ph.D. (Columbia) . . . Assistant Professor of Biomedical Genetics
Timothy Machonkin, Ph.D. (Stanford) . . . Assistant Professor of Biochemistry and Biophysics
Sanjay B. Maggirwar, Ph.D. (India) . . . Assistant Professor of Microbiology and Immunology
David Mathews, M.D. (Rochester) . . . Assistant Professor of Biochemistry and Biophysics
Margot Mayer-Proschel, Ph.D. (Wuerzburg) . . . Assistant Professor of Biomedical Genetics and of Neurobiology and Anatomy
Scott McIntosh, Ph.D. (Missouri) . . . Assistant Professor of Community and Preventive Medicine
Wendy J. Nilsen, Ph.D. (Purdue) . . . Assistant Professor of Psychiatry
Ekaterina Noyes, Ph.D. (Rochester) . . . Assistant Professor of Community and Preventive Medicine
Lisa Opanashuk, Ph.D. (Rochester) . . . Assistant Professor of Environmental Medicine
Martin S. Pavelka, Ph.D. (Rochester) . . . Assistant Professor of Microbiology and Immunology
Derick R. Peterson, Ph.D. (California, Berkeley) . . . Assistant Professor of Biostatistics
Robert H. Pierce, M.D. (Brown) . . . Assistant Professor of Pathology and Laboratory Medicine and of Environmental Medicine
Ellen L. Poleshuck, Ph.D. (Kent State) . . . Assistant Professor of Psychiatry
Douglas Portman, Ph.D. (Pennsylvania) . . . Assistant Professor of Biomedical Genetics in the Center for Aging and Developmental Biology
Ming Qi, Ph.D. (Pittsburgh) . . . Assistant Professor of Pathology and Laboratory Medicine and of Cardiology
Arshad Rahman, Ph.D. (Aligarh Muslim University, India) . . . Assistant Professor of Pediatrics and of Environmental Medicine

* Part time

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Irfan Rahman, Ph.D. (Nagpur University, India) . . . Assistant Professor of Environmental Medicine
Lizabeth M. Romanski, Ph.D. (Cornell) . . . Assistant Professor of Neurobiology and Anatomy
Jason Roy, Ph.D. (Michigan) . . . Assistant Professor of Biostatistics
Sanjeev Sahni, Ph.D. (Kanpur) . . . Assistant Professor of Medicine
Benjamin M. Segal, M.D. (Brown) . . . Assistant Professor of Neurology and of Microbiology and Immunology
Scott H. Seidman, Ph.D. (Case Western Reserve) . . . Assistant Professor of Neurobiology and Anatomy and in the Center for Visual Science
Alice Sijts, Ph.D. (Leiden) . . . Assistant Professor of Microbiology and Immunology in the Center for Vaccine Biology and Immunology
*Patricia J. Sime, M.D. (Edinburgh) . . . Assistant Professor of Medicine and of Environmental Medicine
Tristram Smith, Ph.D. (California, Los Angeles) . . . Assistant Professor of Pediatrics
Jenny Speice, Ph.D. (Virginia Polytechnic) . . . Assistant Professor of Psychiatry and of Family Medicine
Yin Sun, Ph.D. (California, Los Angeles) . . . Assistant Professor of Biomedical Genetics
James Tacci, M.D. (Rochester) . . . Assistant Professor of Community and Preventive Medicine
Toru Takimoto, Ph.D. (Hokkaido, Japan) . . . Assistant Professor of Microbiology and Immunology
Nicholas Theodorakis, Ph.D. (Northwestern) . . . Assistant Professor of Surgery
Sally W. Thurston, Ph.D. (Harvard) . . . Assistant Professor of Biostatistics
Kim Tieu, Ph.D. (Saskatchewan) . . . Assistant Professor of Environmental Medicine
David Topham, Ph.D. (Vermont) . . . Assistant Professor of Microbiology and Immunology in the Center for Vaccine Biology and Immunology
Peter Veazie, Ph.D. (Minnesota) . . . Assistant Professor of Community and Preventive Medicine
Alice Villalobos, Ph.D. (Arizona) . . . Assistant Professor of Environmental Medicine
Brian Ward, Ph.D. (Illinois) . . . Assistant Professor of Microbiology and Immunology
Terry Wright, Ph.D. (Rochester) . . . Assistant Professor of Pediatrics and of Microbiology and Immunology
Shuyuan Yeh, Ph.D. (Wisconsin) . . . Assistant Professor of Urology
Yisang Yoon, Ph.D. (Ohio State University) . . . Assistant Professor of Anesthesiology and of Pharmacology and Physiology
Dabao Zhang, Ph.D. (Cornell) . . . Assistant Professor of Biostatistics and Computational Biology
Jiyong Zhao, Ph.D. (Iowa State) . . . Assistant Professor of Biomedical Genetics
Wei-Ping Zheng, Ph.D. (SUNY, Buffalo) . . . Assistant Professor of Microbiology and Immunology

**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, 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, and toxicology. Both master's and Ph.D. degrees are offered, except in 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 Ph.D. directly, sponsors Ph.D. candidates in several preclinical departments for studies with a direct bearing on dentistry. The Department of Community and Preventive Medicine sponsors the Master of

* Part time
Public Health degree program and the Ph.D. in epidemiology and health services research and policy.

The Ph.D. program in one of the biomedical sciences, or combined with an M.D., provides appropriate preparation for a career in teaching, and research in university, industry, and government. Four interdisciplinary programs are offered: biomedical engineering, genetics, neuroscience, 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 faculty participate in the neuroscience program. The Ph.D. 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 Ph.D. 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 M.S. 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 Ph.D. programs are under the same aegis, but ultimate responsibility for approval of Ph.D. degrees and general regulations rests with the University Council on Graduate Studies and the University dean of graduate studies.

PH.D. DEGREE

The Ph.D. 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 Ph.D. 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 Ph.D. 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.

M.S. DEGREE

Departments offer the M.S. 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 graduate character may be replaced by research credits to varying degrees in special cases where students have already had equivalent training as indicated by the M.D., other higher degrees, or other evidence acceptable to the Committee on Graduate Studies.

The M.S. degree under Plan B is modified and supplemented in many departments in the School of Medicine and Dentistry and is described in the individual departmental announcements. All departments require the writing of an essay and an examination conducted by at least four faculty members of the student; requirements for this degree are given on page 67.

A completed program for the M.S. degree, approved by the department chair and the faculty advisor, must be submitted to the senior associate dean for graduate education as described on page 65 of this bulletin. Only courses integral to the M.S. degree plan and whose subject matter may be included in the final examinations should be listed in this document. If any courses have been taken for other purposes they need not be listed. The number of credit hours expected will vary from department to department but must be at least 30, with distribution consistent with the objectives of the plan.

M.D./PH.D. AND M.D./M.S. PROGRAMS

Students especially interested in a program leading to both the M.D. and the Ph.D. degrees may apply for the combined degree program. The fields in which the Ph.D. 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, pharmacology, physiology, statistics, and toxicology. Areas of the social sciences and business management of particular pertinence to medicine have been developed for an M.D./M.S. degree and are available on an ad hoc basis for M.D./Ph.D. studies.

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* In the arts and sciences; see announcement in this bulletin.
† In the School of Engineering and Applied Sciences; see announcement in this bulletin.
Admission to the combined degree program ordinarily is by joint application to the M.D. and Ph.D. 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 M.D./Ph.D. 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 M.S. and M.P.H. degrees can also be combined with the M.D. 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.
Biochemistry and Biophysics

Associate Professors *Butler, Dumont, Goldstein, Hayes, *Miller, Pearce, *Smrcka, Zain
Assistant Professors †Bayer, Bulger, Hagen, Machonkin, *Theodorakis, Wedekind, Yu
Professors Emeriti Eberle, Kimmich, Marinetti, Miller, Stannard, *Young, Yuile

Biochemistry Degree Programs

The Department of Biochemistry and Biophysics offers programs of study leading to the M.S. (Plan A and Plan B) and Ph.D. degrees in biochemistry. Research areas include enzyme mechanisms; protein chemistry; DNA replication, repair, and recombination; RNA and protein synthesis and processing; molecular 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 Biology in the College. The qualifying examination for the Ph.D. is generally completed by the end of the fifth semester in residence.

REQUIREMENTS

Core Courses (required for all programs of study): IND 408 (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 (M.S. or Ph.D. Research).

Elective Courses (suggested but not limited to): BCH 510 (Enzyme Mechanisms); BIO 402 (Molecular Biology); BIO 419 (Advanced Cell Biology); BIO 426 (Developmental Biology); BIO 451 (Advanced Molecular 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.

M.S. PROGRAM (PLAN A)

The M.S. degree is awarded upon completion of at least 30 hours of credits which 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.

M.S. PROGRAM (PLAN B) AND QUALIFYING EXAMINATION

Upon completion of the required coursework, a research proposal is written which serves as the basis for determining the potential of the student for independent thought and his or her compre-

* Primary appointment in another department
† Part-time

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ension 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.

PH.D. PROGRAM

Students admitted to the Ph.D. program choose a laboratory and advisor at the end of their first year of study after completing at least three laboratory rotations. Ph.D. 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. 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
Credit—four hours
This course is designed primarily for graduate students. 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, workshops are held weekly to analyze examples from the literature. (Fall)

IND 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)

BCH 412. Advanced Topics in Biological Macromolecules
Credit—five hours
An advanced biochemistry lecture course intended for senior undergraduates and graduate students. Topics include DNA and chromatin structure; RNA structure and catalysis; nucleic acid-protein interactions; X-ray crystallography; NMR structure determination; membrane protein structure; protein modification, degradation and folding; protein-protein interactions; enzyme mechanisms; and substrate recognition in cascade reactions. (Spring)

BCH 491. M.S. Reading
Credit to be arranged

BCH 493. M.S. Essay
Credit to be arranged

BCH 495. M.S. Research
Credit to be arranged

BCH 501/502. Seminars in Biochemistry
Prerequisite: BCH 401.
Credit—one hour per term
A student seminar course is offered each semester and continuous registration is required of all graduate students in biochemistry. Seminars are presented by Ph.D. 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 interpreting experimental data and engaging student interactions. (Fall and Spring)

**BCH 517. Cellular and Molecular Sciences**  
Credit—one hour  
Students attend all presentations in the Department of Biochemistry and Biophysics Invited Speaker Seminar Series during the semester. They also attend two pre-seminar classes during the semester. In these classes, one student is chosen to summarize the work of a speaker who presents the following week. That student also distributes manuscripts and other material provided by the speaker prior to the class. All students have a one-hour scientific discussion with the speaker followed by lunch prior to the seminar. Students then submit a short paper reviewing the work of the speaker with a focus on information presented in the seminar (the student who summarized the material in class will be exempt from this requirement). (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 the regulation of eukaryotic gene expression. The purpose is to familiarize students with a variety of contemporary research methodologies through student-led discussions of current publications in the field. Past topics have included cell cycle regulatory proteins, steroid receptors and coactivators, and mechanisms of histone acetylation. (Spring, odd-numbered 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 Ph.D. 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 and physical chemistry 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, and chemistry in the College. Collectively this group of faculty and their students form the Biophysics and Structural Biology Cluster (BSB).

BSB 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 is experienced at bringing students from the physical/chemical sciences up to speed 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, General 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 and Structural Biology cluster 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. Ph.D. 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 Ph.D. 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; physics or permission of the 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)

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 systems. 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. (Fall)

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 Ph.D. 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. Ph.D. 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.

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BPH 595. Ph.D. Research
Credit to be arranged

The fields open for dissertation research are listed in the preceding general description for

Biostatistics and Computational Biology

Professors *Hall, Oakes, Tu, Wu, Yakovlev (Chair)
Associate Professors Huang, Liang, McDermott, Peterson, Zhao
Assistant Professors Almudevar, Beck, Gordon, Hyrien, Ma, Roy, Thurston, Wang
Joint Appointments: Professors Fisher, Mathews, Mudholkar, Poduri, Qin, Sharma

The activities of the Department of Biostatistics and Computational Biology include biostatistical research, collaborative research, and teaching. The department conducts a program of teaching and research in statistical methodology oriented toward the health sciences and in statistical theory and stochastic modeling growing out of research in the health sciences. The department has recently expanded to include a unit devoted to methodological and collaborative research in the rapidly emerging area of computational biology, as well as a unit devoted to biocomputing and modeling for clinical studies. Department faculty have wide-ranging research interests, including survival analysis, sequential analysis, clinical trial design, longitudinal data analysis, missing data methods, causal inference, analysis of categorical data, measurement error models, multiple testing, analysis of gene expression data, network inference, statistical genetics, nonparametric smoothing and curve estimation, model selection techniques, robust inference, mathematical and stochastic modeling of complex biological systems, order restricted inference, ROC curve analysis, nonparametric inference, Bayesian inference, functional response models, and small-sample asymptotics. The department has expertise in virtually all fields of modern theoretical and applied statistics.

Faculty of the department have played major roles in important breakthroughs in medical research at Rochester. Examples include the better understanding of the role of calcium channel blockers in treating patients who have had a heart attack, demonstration of both the clinical effectiveness and the cost effectiveness of implantable defibrillators in reducing mortality among certain heart disease patients, demonstration of the effectiveness of deprenyl in slowing onset of disability in early Parkinson's disease, and of surfactant therapy for respiratory distress syndrome in premature infants, and an ongoing epidemiologic study of the assessment of the effects of low levels of dietary mercury intake on childhood development. Faculty are currently involved in wide-ranging collaborative activity with the Environmental Health Sciences Center, the Cancer Center, the Center on Aging and Developmental Biology, the Center for Oral Biology, the General Clinical Research Center, the Heart Research Follow-Up Program, the School of Nursing, and the Departments of Medicine, Neurology, Community and Preventive Medicine, Pediatrics, Psychiatry, Emergency Medicine, Obstetrics and Gynecology, Ophthalmology, Dentistry, and Biomedical Genetics. The department houses the Biostatistics Centers for national and international research groups such as the Parkinson's Study Group, Huntington's Study Group, Muscle Study Group, and Tourette's Syndrome Study Group and is responsible for the statistical analysis of many recent and ongoing multicenter clinical trials of new treatments for those diseases. This environment is ideally suited for collaborative research and consulting.

The department administers masters, doctoral, and postdoctoral programs in statistics. Faculty provide instruction to Medical Center faculty, fellows, postdoctoral trainees, and graduate students for each degree program. Laboratory space and equipment are available in sufficient variety and depth to accommodate a large range of research interests.

* Part-time
from basic science and clinical departments through a sequence of courses in biostatistical methods and clinical trial design (BST 463, 464, 465, 466). Various occasional lectures and informal short courses are also offered.

A training grant in Environmental Health Sciences Biostatistics funded by the National Institute of Environmental Health Sciences (NIEHS) supports predoctoral and postdoctoral training.

Up-to-date computer hardware and software are available to support biostatistical research, consulting, and teaching.

PH.D. DEGREES

Program for the Degree of Doctor of Philosophy in Statistics

The department administers the doctoral program in statistics, which is taught jointly by biostatistics faculty and faculty of the Program in Statistics in the College. 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 Ph.D. 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.

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, 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. This course (1) provides students with experience in organizing, preparing, and delivering oral presentations; (2) introduces students to the process of searching the statistical literature; (3) enables students to acquire knowledge of a focused area of statistical research; and (4) introduces students to the research interests of members of the faculty. 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:
## Year 1: Fall
- BST 401 (4 credits)
- BST 411 (4 credits)
- BST 464 (4 credits)
- BST 497 (1 credit)
- BST 590 (2 credits)
- IND 501 (1 credit)

## Year 1: Spring
- BST 412 (4 credits)
- BST 426 (4 credits)
- BST 466 (4 credits)
- BST 497 (1 credit)
- BST 590 (3 credits)

## Year 1: Summer
- BST 477 (0 credits)
- BST 478 (0 credits)

## Year 2: Fall
- BST 402 (4 credits)
- BST 511 (4 credits)
- BST 514 (4 credits)
- BST 497 (1 credit)
- BST 590 (3 credits)

## Year 2: Spring
- BST 479 (4 credits)
- BST 520 (4 credits)
- BST 531 (4 credits)
- BST 497 (1 credit)
- BST 591 (3 credits)

## 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. Ph.D. 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 Ph.D. students are required to have at least four credits of supervised teaching and/or supervised consulting (BST 590, 592).
4. 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
   - Semiparametric Inference
   - Smoothing Methods
   - High-Dimensional Data Analysis

   Statistical Methods in Epidemiology
   The Bootstrap, The Jackknife, and Resampling Methods
   Introduction to ROC Methodology
   Statistical Inference Under Order Restrictions
   Monte Carlo Methods and Modeling of Biomedical Dynamic Systems

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 M.D./Ph.D. Program
Students admitted to the M.D./Ph.D. program follow essentially the same course of study as students in the Ph.D. program, except that coursework in statistics begins during the fall of the third year.
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 a formal reading course (BST 491) 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 M.A. program are the same as those for entry into the Ph.D. program. The M.A. 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 Ph.D. program receive an M.A. 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 M.S. 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 470), 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 M.S. 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:

<table>
<thead>
<tr>
<th>Fall</th>
<th>Spring</th>
<th>Summer</th>
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</thead>
<tbody>
<tr>
<td>BST 411 (4 credits)</td>
<td>BST 465 (4 credits)</td>
<td>BST 470 (8 credits)</td>
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<tr>
<td>BST 464 (4 credits)</td>
<td>BST 466 (4 credits)</td>
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<tr>
<td>BST 421 (4 credits)</td>
<td>Elective (4 credits)</td>
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</tbody>
</table>

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; multivariate chi-square tests.

413. Bayesian Inference
Prerequisite: BST 411.

Introduction to statistical decision theory; loss functions; admissibility; Bayes and empirical Bayes procedures; hierarchical models; noninformative and informative prior distributions; modern numerical 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 165 or STT 203.

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 T^2; 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 and BST 476. Credit—two hours

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.

Chi-square tests for independence; mutual, partial, and conditional independence; Cochran-Mantel-Haenszel methods; loglinear models for analysis of two-way and three-way contingency tables; logistic regression; Poisson regression; models for nominal and ordinal categorical responses; analysis of matched-pair categorical data; “exact” methods for inference; interactions; goodness-of-fit; model checking; introduction to survival analysis, including Kaplan-Meier curves and the Cox proportional hazards regression model.

470. Internship/Applied Project
Credit—eight hours

As required for completion of the M.S. 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.

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 S-Plus. 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

495. Research at the Master’s Level
Credit—varies

497. Seminar in Statistical Literature
Credit—one hour

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.

525. Introduction to Health Informatics

Introduction to health informatics; clinical data and biomedical knowledge; electronic medical records and integrated health care information systems; standards for health information technology; natural language and text processing/information retrieval; human factors in health informatics; translational informatics and decision support systems; public health informatics, telemedicine, and patient monitoring; evaluation of health care information systems; consumers, Web, and health education.

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 Ph.D. Level
Credit—varies

Special work for doctoral candidates, arranged individually.
Community and Preventive Medicine

Professors *Brown, Pearson (Chair), *Phelps
Assistant Professors Adams, Chin, *Davidson, Dick, Dozier, Fernandez, Hart, *Lavigne, McIntosh, Noyes, Tacci, Veazie
Adjunct Professors Mukamel, *Woodard
Research Associate Professor Temkin-Greener
Instructors Braus, Tomaszewski
Senior Associate *Coburn
Research Associates Arkoulis-Sinclair, Guido
Professors Emeriti Barker, Kunitz, Zimmer

The Department of Community and Preventive Medicine offers programs of study leading to the degrees of Master of Public Health and Doctor of Philosophy in both health services research and policy in epidemiology. Within the M.P.H. program, there is a Generalist track and a Clinical Investigation track (latter requires M.D., D.O., D.D.S., Ph.D.). The Master of Public Health (M.P.H.) is 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 M.P.H. Generalist track is approximately 51 credit hours. It can be completed in two years of full-time study. The M.P.H. Clinical Investigation track is 32 credits. It 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 M.P.H. 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 program of study leading to the Ph.D. in health services research and policy is predicated on the belief that there is a critical need in academia, government, and the private sector for health care researchers. These researchers require backgrounds in statistics, economics, and policy analysis combined with an understanding of the institutions, structure, and functioning of the U.S. health care system. They also require knowledge of the important issues in health services research and policy and a command of the special methods and research approaches that have been developed specifically in this field. In the Ph.D. program offered at the University of Rochester, there are special tracks for students interested in health systems research and policy and clinical decision and evaluation sciences.

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 in epidemiology, while encouraging the integration of multiple disciplines in health investigations that span the biopsychosocial continuum. Graduates will have mastered a unique

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* Primary appointment in another department
set of methodologic and analytic skills necessary for the practice of preventive medicine and the formulation of public health practice. Currently, there is a significant demand for epidemiologists interested in research and education to assume positions in public health organizations, universities, government, and industry.

The M.P.H. program can be combined with the M.B.A. program or the M.D. program. A combined 3-2 B.A./M.P.H. program allows for the acceptance of a limited number of University of Rochester undergraduates at the completion of their third year of study.

The M.P.H. program can be combined with the M.B.A. program or the M.D. program. The M.P.H. program can also be combined with the 3-2 program. The 3-2 program allows for the acceptance of a limited number of University of Rochester undergraduates at the completion of their third year of study.

Eligibility for Admission: Candidates for admission to the program must have earned a baccalaureate degree, or the equivalent, with the exception of University of Rochester undergraduates applying to the 3-2 program. Applicants must submit a completed application form; transcripts from all previous academic work; at least two letters of recommendation from former instructors or employers; score reports from the Graduate Record Examination aptitude tests or the equivalent (taken within the past five years); and a sample of written work (other than the application essay). The TOEFL (Test of English as a Foreign Language) is required of applicants from foreign countries where English is not the primary language. When possible, applicants will be interviewed by faculty members. Applicants are encouraged to apply by June 1 for the fall semester. Selection is based on the previous experience and academic record of the candidate, and on evidence of interest in and serious commitment to a career in the fields for which the program is designed. Applicants who wish to pursue the M.P.H. degree on a part-time basis will be considered. Partial tuition assistance and research and teaching assistantships are available to qualified full-time M.P.H. students. Doctoral students are eligible to receive tuition assistance and a stipend. More detailed information on each of the combined degree programs is available upon request.

Application: Inquiries may be addressed to, and application forms requested from, the program director:

Director of Graduate Studies
Department of Community and Preventive Medicine, Box 644
University of Rochester School of Medicine and Dentistry
601 Elmwood Avenue
Rochester, New York 14642-8644
Telephone: (585) 275-7882 or fax: (585) 461-4532
E-mail: cpm_admissions@urmc.rochester.edu
Web site: www.urmc.rochester.edu/cpm/index.html

The Department of Community and Preventive Medicine is housed on the fourth floor of Helen Wood Hall, 255 Crittenden Blvd.
410. Introduction to Data Management and Data Analysis Using SAS
Prerequisite: BST 463 or permission of the instructor.

This course, targeted at M.P.H. students, provides an introduction to the SAS analytic software as applied to the management, analysis, and reporting of clinical and public health data. Building on linkages to the department's biostatistics and epidemiology curriculum, this course emphasizes the integration of SAS into the research environment and the development of extensible statistical computing skills. Students gain familiarity with the SAS system through a combination of collaborative lab sessions, homework assignments, and illustrative public health examples. To enroll, students must have a working knowledge of Microsoft Windows and be familiar with basic statistical concepts (as covered in BST 463 or an equivalent course). (Fall)

411. Health Care for the Elderly: Financing and Organization
Credit—3 hours

The aging of the U.S. population and the projected growth of the "oldest old" will have a major impact on the demand for and the supply of services and resources needed to care for this population. Already today, older Americans with serious and disabling chronic conditions are the largest, highest-cost, and fastest-growing consumer group. What are the needs of this growing demographic? How is the U.S. health care system responding to those needs? What kinds of services are available, how are they managed, and are they sufficient? Who provides the care? How much do those services cost? Who pays for what? What about quality of care? These and other issues important to the financing and the organization of health services for older Americans are examined in the course of this seminar. (Spring)

412. Survey Research

This course provides 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. Components of the course include survey item design, recruitment and follow-up strategies, pilot testing methods, IRB considerations, and psychometric issues. (Spring)

413. Field Epidemiology
Prerequisite: introduction to epidemiology or permission of 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. (Fall)

414. History of Epidemiology

This course familiarizes the student with the growth of epidemiology, as a basic science, and shows the interrelationship 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 of 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 methodologic 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 from its roots to its dynamic responsibilities in present trends. (Fall)
415. Principles of Epidemiology
This course provides an introduction to epidemiologic concepts of disease and interventions to ameliorate them. Discussion of population-based aspects of disease, morbidity and mortality statistics, basic study designs (cross-sectional, case-control, cohort, and clinical trials), and the use of epidemiologic data to draw conclusions about disease causation. At the end of the course, students should have a broad view of denominator-based research and be prepared for higher-level courses in epidemiologic methods. (Fall)

416. Epidemiologic Methods
Prerequisites: PM 415 and one semester of graduate-level statistics or permission of instructor.

This course is designed to provide an in-depth coverage of the quantitative methodologic issues associated with population-based epidemiologic research. Issues specific to study design, statistical analysis, confounding, effect-modification, and multivariate analytic techniques including logistic and Cox proportional hazards modeling. Two data analysis projects are required during the semester to provide the student with a hands-on experience. (Fall)

417. Molecular Epidemiology
Prerequisite: PM 415.

Using the same paradigm as traditional epidemiology, this course explores the opportunities for the use of increasingly powerful biologic markers of exposure, disease, or 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
Credit—three hours

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, the emerging risk factors for CHD, strategies and interventions for preventing CHD, the difference between risk markers and risk factors, the process of identifying and verifying that a risk marker is truly independent, the known and suspected risk factors for stroke, and the current controversies in CVD EPI and prevention and how they have arisen.

420. Politics and Policy in the U.S. Health Care System
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 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. One five-page analytical paper and one 20-page research paper required. (Fall)

421. Introduction to the U.S. Health Care System
This course is intended to provide an overview of the U.S. health care system. This includes a description of the major components such as hospitals, physicians, managed care plans, and long-term care institutions; finance and reimbursement processes such as DRGs and RBRVS; and system outcomes such as quality and access. The course is intended to provide a comprehensive summary allowing the student to place more detailed studies in context. (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 effectiveness and efficiency of clinical practices, medical technologies, health services, and policies. The material covered introduces the analytic approaches, databases, and settings available for studies addressing clinical practices, patient preferences and satisfaction, practice patterns, interventions, 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)

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 the application of behavioral, sociological, and anthropological science approaches to the etiology, prevention, treatment, and management of physical disease and illness; and on 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)

427. Neurodevelopmental and Related Disorders
This course provides a conceptual framework for development of leadership in the field of neurodevelopmental disabilities. Students are guided in correlating their own personal characteristics with their leadership type. The environment in which services for individuals with neurodevelopmental disabilities are provided is examined including legislative influences, fiscal constraints, service models, and societal values.

428. Health Services Research Seminar
Credit—none
A noncredit course required of all doctoral and postdoctoral students. A variety of topics are presented for discussion by faculty and students.

429. Introduction to SAS for Windows
Prerequisite: BST 463 or equivalent and knowledge of MS Windows.
This half-semester course, targeted at MPH-CI students with an understanding of statistics and study design, provides a basic introduction to the SAS analytic software for Windows. Through a mixture of lectures and applied lab sessions, students gain experience using the SAS system for the management and analysis of public health data. Building on linkages to the department’s biostatistics and epidemiology curriculum, this course emphasizes the integration of SAS into the research environment and the development of extensible statistical computing skills. This course is only open to matriculated students in the department’s Master of Public Health—Clinical Investigation (MPH-CI) track. To enroll, students must have a working knowledge of Microsoft Windows and be familiar with basic statistical concepts (as covered in BST 463 or an equivalent course). (Summer)

433. Epidemiology and Public Health of Aging
The twentieth-century demographic transition to an aging society is a universal phenomenon with profound implications for present and future disease patterns and health services. This course provides students with a working knowledge of major epidemiologic studies of disease and disability associated with the epidemiologic studies of disease and disability associated with the aging population and of the application of contemporary public health and medical care strategies to these emerging patterns. Concepts covered include compression of morbidity, functional status assessment, active life expectancy, essential roles of public health. Student evaluation is based upon several written assignments and presentations during the course and a final paper. (Fall)

436. Health Policy
Prerequisites: statistics and PPA 407.
Analysis of factors that affect supply and demand in the market for medical care: risk, insurance, externalities, and regulation. (Fall)

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)

439. Seminar in Health and Health Care of the Elderly
The goal of this course is to provide a basic multidisciplinary perspective to the health and health care of the elderly and, through seminar presenters from a wide variety of institutions, departments, and programs, stimulate students’ interest in and interaction with the variety of institutions and programs that deliver health care services to the aged. This course focuses exclusively on persons 65 and older, with special attention being paid to specific diseases and con-
ditions that are prevalent in the elderly as well as mechanisms and organizations that provide their health care and social services. Examples of seminar topics include Living at Home with Chronic Illness and Disability, Employment and Retirement, Legal and Ethical Issues in End of Life Decisions, and Successful Aging.

440. Legal Issues in Health Care
Prerequisite: PM 420.
This seminar exposes students to a broad array of the legal issues that arise in the context of health care and health services. Topics include the legal basis for government involvement in health care, the rights of patients and providers, including principles that have developed for the protection of specific patient groups including infants, children, and those who lack capacity, and the legal aspects of health care financing and regulation. (Fall)

441. Methodological Issues in Conducting Research on Elderly Populations
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 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. (Spring)

442. Nutritional Epidemiology
Prerequisites: introductory courses in epidemiology and statistics.
The course is designed to give the 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 breastfeeding, new national and international growth curves, examples of the role of diet in cancer prevention). The course is focused mainly but not exclusively on maternal and child health issues. (Spring)

443. Maternal and Child Health Epidemiology
This course provides an overview of current topical and methodological issues in maternal and child health epidemiology. Topics covered include identification of MCH indicators; epidemiological performance and organization of MCH services; analytic techniques in MCH epidemiology; race and ethnicity; maternal, fetal, infant, and child mortality analyses; morbidity in pregnancy and infancy; social determinants of MCH problems; and perinatal regionalization. Students are expected to use the Internet in the conduct of coursework. Guest speakers present practical applications of MCH epidemiology in public health and medicine. (Fall, alternate years)

445. Introduction to Health Services Research and Policy
Credit—three hours
This course introduces students to the field of health services research and policy. The primary objective is making students aware that HSR&P is a multidisciplinary field, both basic and applied, that examines the use, costs, quality, accessibility, delivery, organization, financing, and outcomes of health care services. The course examines the historical development of the field, introduces the basic concepts and methods of social science research as they apply to HSR&P, provides an overview of the field’s different major theoretical foundations, and introduces students to critical reading and evaluation of the HSR&P literature. (Fall, alternate years)

447. Workshop in Technology Transfer/Working with Industry
This workshop is a joint effort by the Office of Technology Transfer and the Rochester Clinical Research Curriculum, with its overall goal to introduce trainees and faculty to the relationships between university-based research and private industry. The workshop recognizes that universities are a growing source of intellectual property for which credit and benefits to the university need to be recognized. At the same time, the private sector is a growing source of research and development support, career opportunities, and the means to apply and disseminate discoveries. This 11-week workshop explores a number of issues to prepare the university-based researcher for productive interactions with industry. This workshop series provides an introduction to types and sources of research funding, including the UR SMART system. It also addresses legal issues in clinical research, copyright, patenting, licensure, and other intellectual property issues, as well as program management and marketing by industry. (Fall)
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)

449. The Writing Workshop
Strong writing skills are an asset in public health research, business, and public life. This workshop addresses word usage, effective use of outlines and quotations, the use of transitions and other components of good writing. The two-part class features five writing workshop sessions followed by individual tutorial sessions with a subgroup of students. (Fall)

450. Management and Evaluation of Health Services Organizations
Prerequisite: one semester of epidemiology or permission of instructor.
This course provides an understanding of executive-level management and leadership in nonprofit health and human service organizations. In addition, students study organizational context, program design and implementation, and the evaluation of health care services. Students complete a health and human service not-for-profit agency-based project that involves an analysis of management and leadership issues, as well as an exercise that is a component of a needs assessment, program evaluation, or quality assurance assessment. (Spring, May, June)

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. (Spring)

452. Community Health Improvement Practicum
Credit—three hours
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. To help them become key partners in the community who are able to help effect positive changes in health on a broader scale.

453. Child and Adolescent Epidemiology
Topics cover three age groups: preschool, school-age, and adolescence. Course goals are to present an overview of current issues in child and adolescent epidemiology. The course familiarizes students with the tools to understand the epidemiologic literature in order to make informed public health decisions based on available scientific evidence and to analyze epidemiologic data on child and adolescent issues. (Spring)

454. Global Health Informatics
This course presents students with an overview of trends in a wide range of global public health indicators and the methodological tools available for addressing the analysis of international health data. The course prepares students to conduct research in international settings and focuses upon the blending of methodologies to achieve research objectives. Further, the course emphasizes Internet tools and modes of communication to facilitate the conduct of global health research. Students are required to conduct an Internet-based project sequentially conducted throughout the semester in consultation with public health researchers and officials in a variety of international settings. The course emphasizes hands-on, applied analyses of global health issues. (Fall, alternate years)

456. Advanced Health Economics II: The Industrial Organization of Health Care Markets
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 and game theory, integration, the role of information, regulation, and antitrust laws. (Spring)

458. Qualitative Health Care Research
The increasing complexity of health services and their delivery requires the search for new research methods. Qualitative methods, long used in the social sciences, allow access to areas that quantitative methods cannot adequately access such as health beliefs or actual (as opposed to stated) health or health delivery practices. In addition, qualitative methods can function as a prerequisite to quantitative methods by hypothesis generation or identifying lay terminology for accurate survey developed. This course covers standard qualitative methodologies through readings from the literature and discussion. (Spring)

459. Assessing Health Status of Older Adults
Students typically read about various assessment instruments that are used to measure the health status of the elderly but often do not have the opportunity to administer them unless
they are in a clinical educational program. The objective of this course is to give them such experience through field trips to various settings including nursing homes, assisted living facilities, adult day care programs, senior centers, and patients’ homes where home care agencies provide services. We cover Activities of Daily Living and Instrumental Activities of Daily Living, the Mini Mental State Exam, the Geriatric Depression Scale, social functioning, the SF-36, the nursing home Minimum Data Set, and several performance-based measures. The class is limited to four to six students, and preference is given to students interested in receiving our Graduate-Level Certificate in Health & Aging. (Fall)

460. Master’s Essay
Credit—six hours or 12 hours with Honors Essay (with prior approval of the faculty)

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.

462. Genetic Epidemiology
The goal of genetic epidemiology is to understand the genetic etiology of disease through the study of genetic characteristics and their interactions with environmental exposures. This provides a framework for understanding the etiology and distribution of disease among relatives and within diverse human populations, which can facilitate early identification of high-risk individuals and families and inform the development of effective interventions.

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
Prerequisite: PM 463 or permission of instructor.

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
Rather than concentrating on theory and math, this course focuses on hands-on training. By the end of the course, students should be comfortable performing routine statistical and econometric analysis, testing the assumptions of the standard ordinary least squares regression model, and presenting and interpreting data. Students should also be comfortable working with Stata. (Spring)

466. Cancer Epidemiology
The purpose of this course is to provide students with a basic understanding of the biology, prevention, treatment, and burden of malignancy in the United States. The course includes discussions of patterns of cancer incidence, etiologic factors, individual risk assessment, stages of neoplastic development, recent laboratory techniques for measurement of biomarkers, and interventional approaches related to prevention, screening, and treatment. Seminars are generated from a series of selected papers from the literature, each representing either a seminal contribution or a new strategy in cancer research. In-depth critiques of the research design and statistical approaches of each paper are also included.

467. Cancer Screening and Prevention
The purpose of this course is to provide students with a strong background in the principles of disease screening, diagnostic test usefulness, and implications of public health policies related to cancer screening. Major cancers sites for which screening recommendations are available are discussed. The implications of screening related to human costs are considered. Seminars are generated from a series of selected papers from the literature.

468. Epidemiology of Mental Disorders
The goal of this course is to understand the etiology and distribution of mental disorders, including major depressive disorders and suicidal behaviors, anxiety disorders, schizophrenia, late-life dementias and other disturbances of mental behavior. Emphasis is placed on identifying and understanding an epidemiologic framework for risk factor research and its application for developing and implementing universal, selected, and targeted interventions in diverse populations as defined by the Institute of Medicine. Therefore, the epidemiology of alcohol and drug dependence, including other drug dependence such as cocaine, is also considered. Issues related to ethical conduct of mental health-related research across the life cycle are discussed.
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. Detailed presentations of the analysis issues of confounding and interaction are presented and a complete presentation of most multivariate techniques. To reinforce understanding, students are required to complete exercises that assure practice and experience with the application of each technique.

470. Public Health and the Environment
The objective of this course is to present an overview of public health issues that are associated with the environment. Areas of emphasis include the evolution of environmental health from its roots in communicable diseases; current environmental health issues; epidemiology of occupational hazards and their relevance to public health; environmental health policy and regulation; and the prevention and control of environmental hazards. (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 research instruments for epidemiologic research purposes. A review of the principles of survey development begins the course, however, it rapidly moves to the comparative analysis of various instrument designs as well as testing of these tools.

476. RCRC Seminar Series
A weekly seminar series for Rochester Clinical 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.

477. Advanced SAS Programming for Statistical Analyses
The purpose of this course is to provide students with more advanced knowledge and experience in SAS programming. As an extension of the Introduction to SAS class, this more accelerated course presents advanced file manipulation techniques in order to conduct multivariate analyses and modeling of follow-up data. Methods included are programming steps for ANOVA, linear regression, generalized linear models, logistic regression, and survival analysis (time to event). A detailed presentation that links statistical testing presented in other courses to software availability and programming is included. (Spring)

478. Workshop in Scientific Communication
Credit—none
A noncredit course required of all Rochester Clinical Research Curriculum trainees, Ph.D., and postdoctoral fellows. This workshop series addresses the principal elements of scientific presentation and communication such as abstract preparation, poster development, slides preparation, manuscript review and critique, oral presentations, and working with the media/public relations. (Spring)

PM 479/HIS 208. 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)

481. Public Health Practice
This course focuses upon systematic approaches to public health decision making and upon the role of evidence, method, and community collaboration in the practice of public health. Of particular interest in this class is the collection and assessment of evidence in public health practice and of the central role of public health data in the assessment process. The class draws significantly upon local (Monroe County) experience in the assessment of community need through the Health Action community coalition process, through the Health Action Report Card surveillance and tracking approach, and through case studies of specific areas of public health where evidence has been systematically evaluated and published (immunization, cardiovascular disease prevention, lead poisoning prevention, and child health and nutrition). Students gain experience using Healthy People 2010 indicators and the corresponding Data 2010 surveillance system for tracking HP 2010. Students gain competency in using risk statistics (e.g., population attributable risk percent, summary odds ratios) as tools for prioritizing health problems. Finally, students gain appreciation for the process of developing community-public health partnerships to deploy public health
interventions. Guest speakers provide lectures addressing course priorities and content areas. (Spring)

482. Clinical Evaluation and Outcomes Research
Prerequisite: one semester of graduate-level statistics or of epidemiology.

This course covers the types of study design and settings available for original observations about clinical interventions and practice patterns. It focuses on the use of patient populations and databases as laboratories for the generation of new knowledge and information. Ways to improve the outcome and efficiency of personal health services through evaluating their effectiveness, quality, appropriateness, and cost are explored. The material covered introduces the methods, databases, and settings available for such studies. (Spring)

483. Advanced Health Economics, Part I
Prerequisite: Knowledge of the U.S. health care system and microeconomic theory.

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, alternate years)

484. Cost-Effectiveness Research
Prerequisite: one semester of graduate-level statistics.

Decision analysis 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 concepts underlying the quantitative analysis of medical decisions. They are provided with the basis to understand decision and cost-effectiveness analyses, which appear in the clinical and health services research literature as well as to be able to set up and perform such analyses themselves. (Spring)

486. Medical Ecology
Credit—three hours

This course is suited for students who wish a research-oriented, multidisciplinary approach to the study of environmental impacts on human health. It draws heavily on a global approach and generates locally relevant lessons from case studies from around the world. Students are actively engaged in analyzing and generating case studies and are expected to be comfortable with a multidisciplinary approach (integrating social, biological, and physical sciences) to examining illness, injury, and disease. Completion of this course fulfills the M.P.H. departmental requirement for environmental health. (Fall)

494. Special Topics in Preventive Medicine
Credit to be arranged

Special studies and investigative projects can be arranged with individual members of the department in the areas of medical care research, medical economics, medical sociology, health care administration and policy, and epidemiology.

Dentistry

Professors Bahreman, Berkowitz, Billings, Bowen, *Caton, Graser, Melvin, Meyerowitz (Chair), Subtelny, *Tallents, Westesson
Associate Professors Ercoli, Fong, Jiang, Kyranides, Malmström, *Oster, *Pollan, Quivey, *Romano, Saunders, Teng, Thierer, Watson

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 M.S. or Ph.D. degree in one of the basic medical sciences or an M.S. degree with a major in dental sciences as described under the Center for Oral Biology. Both the M.S. and Ph.D. programs are open only to postdoctoral students who already hold a D.D.S., D.M.D., 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 M.D. degree linked to their residency training.

* Part-time.
M.S. and Ph.D. candidates are registered with the basic science department where the degree will be granted and are required to fill the requirements of coursework and research in that department.

Genetics

Professors Bambara, Berk, Bohmann, Dewhurst, Eickbush, Federoff, Frelinger, Goldfarb, Gorovsky, Hattman, Hayes, Hinkle, Land, Maquat, Noble, O'Keefe, Palis, Phizicky, Pinkert, Rowley, Sherman, Smith, Werren, Associate Professors Butler, Dumont, Freeman, Giger, Jordan, Mayer-Pröschel, O'Reilly, Pearce, Assistant Professors Bi, Bottaro, Bulger, Chen, Fowell, Fry, Gan, Hagen, Hsu, Jasper, Jiang, Kim, Li, Maggirwar, Portman, Pröschel, Rempe, Sun, Zhao, Research Associate Professor Grayhack

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 chose one of the labs that have hosted the rotations for their Ph.D. 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 will 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. 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 Ph.D. in genetics.

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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 Orthopedics, 9Department of Pathology and Laboratory Medicine, 10Department of Pediatrics, 11Department of Pharmacology and Physiology.
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 designed primarily for graduate students. 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, workshops are held weekly to analyze examples from the literature. (Fall)

IND 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)

IND 501. Ethics in Research
Credit—none
This course is offered online and is required of all first-year graduate students and new post-doctoral 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.

GEN 503/504. Genetics Seminar
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
This course constitutes in-depth discussions of several genetic model systems, including yeast, Drosophila, Caenorhabditis elegans (a nematode), mouse, and human. 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 and nematode genetics illuminate the general principles behind the control of pattern formation and the cell fate specification in complex organisms across wide evolutionary scales. The mouse model illustrates an alternative approach to vertebrate genetics.

GEN 595. Ph.D. Research
Ph.D. 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.

MBI 421. Microbial Genetics
An in-depth examination of some representative genetic systems in bacteria and bacterial viruses. Topics include mutations and mutagenesis, recombination and repair, mechanisms of genetic exchange, transposable elements, and the control of gene expression. (Alternate years)

IND 443. Eukaryotic Genome Organization and Expression I
This course examines in detail the organization of eukaryotic genomes and the mechanisms and control of gene expression. Topics include content and arrangement of DNA sequences in the genome, structure of specific genes, RNA synthesis and processing, and the structure and composition of chromatin and chromosomes.

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 473. Immunology
Innate and adaptive immunity; structure and genetics of immunoglobulins and T cell receptors; lymphocyte development, immune regulation, immunological diseases, tumor immunity. (Fall)

GEN 508. Genes, Development, and Disease
A graduate-level developmental biology course aimed at providing students with the up-to-date scientific information and background knowledge behind the biomedical research into the molecular mechanisms of normal developmental processes and diseases. The course runs in modular format with lectures and student reading/presentations in each module. Seven biweekly modules are taught, each by an instructor(s) most familiar with the topic. The modules include embryogenesis in human and model organisms; hematopoiesis; CNS development; organ formation and developmental disorders; genomics and proteonomics; modeling and systems biology; and cancer.

Interdepartmental Courses

Described below are interdepartmental courses for intercollege programs and other purposes. These offerings draw widely on the special qualifications of the faculty in the area independent of faculty departmental affiliations. They should be considered in conjunction with the courses, especially advanced courses, and in the closely allied subjects offered by the individual departments. The courses numbered in the 400 series are taught at a level suitable for beginning graduate students and advanced undergraduates. All courses listed under this heading should be entered on registration materials with an “IND” designation.

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 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 the
lectures, workshops are held once a week, during which time selected papers from the literature are discussed. (Fall)

409. Cell Biology  
Credit—four hours  
This course is designed primarily for graduate students. 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, workshops are held weekly to analyze examples from the literature. (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—two hours  
This course is designed to provide graduate students in the sciences with the opportunity to gain experience in science education. The course covers theories, principals, and concepts of science education. Students learn effective methods for communicating scientific knowledge and the process of inquiry to undergraduates, secondary students, and the general public.

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—Biomedical Sciences  
Credit—one hour  
This course is required of graduate students and postdoctoral fellows in the biomedical sciences in the School of Medicine and Dentistry. The course features six modules that provide information about the various topics that the National Institutes for Health consider essential to understanding the responsible conduct of research. 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)
503. Ethics and Professional Integrity in Research—Clinical
Credit—one hour

This course is required of students in the Master of Public Health Program, Clinical Track, in the Ph.D. programs in Epidemiology and Health Services Research and Policy, and for postdoctoral fellows in clinical disciplines in the School of Medicine and Dentistry who are supported by federal training grants. The course features six modules that provide information about the various topics that the National Institutes for Health consider essential to understanding the responsible conduct of research. The course is offered in a lecture, clinical case study, and small discussion group format. (Fall)

507. Advanced Genetics
Prerequisite: introductory course in genetics.
Credit—four hours

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)

Laboratory Animal Medicine

Professors Baggs, Wyatt
Associate Professor Moorman-White
Assistant Professor Bates
Residents Williams, Winterborn

Graduate instruction is offered by the faculty of the Division of Laboratory Animal 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 three-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 an independent research project mentored by a department faculty member.

402. An Introduction to Laboratory Animal Biomethodology
Prerequisite: B.S. in biological sciences or professional degree (M.D., D.D.S., or D.V.M.).
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)

Marriage and Family Therapy

Assistant Professor Horwitz, Nilsen
Joint Appointments: Professor McDaniel; Associate Professors *Gawinski, le Roux (Director), Shields, Watson; Assistant Professors Poleshuck, Seaburn, Speice; Associate Rousseau
Senior Instructor Pisani
Clinical Associate Professor Driscoll
Clinical Senior Instructors Briody, McCabe, Karl, Klausz, Platt
Professor Emeritus Wynne

The Department of Psychiatry offers a Master of Science degree in marriage and family therapy through the Family Therapy Training Program, an international leader in medical family therapy. 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 faculty is recognized for developing Transitional Family Therapy, a model that blends structural, transgenerational, and ecosystemic approaches, while using family strength and competence in therapy. The trainee is provided with an in-depth opportunity to integrate family therapy theory and techniques with issues of culture, ethnicity, gender, health, and larger systems concepts.

Family programs 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 prides itself on training professionals from multiple disciplines (medicine, nursing, social work, psychology, clergy, education) and serving disadvantaged populations.

The goals of the M.S. 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 competent 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. All courses are taught by experienced family therapy faculty, and all clinical supervisors are approved supervisors or supervisor candidates in the American Association for Marriage and Family Therapy (AAMFT).

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. Each student has a clinical placement in one of several settings. These include the Strong Family Therapy Services in the Division of Family Programs (Strong Behavioral Health), as well as numerous off-site clinics, including a community hospital, primary care health center, program for the seriously and persistently mentally ill, community mental health centers, and school-based and home-based programs.

Applicants typically have a bachelor's degree in education, psychology, social work, sociology, or nursing. In order to graduate, students must successfully complete 45 credit hours in a clinical practicum.

* Part-time.
All courses meet the standard curriculum requirements of the Commission on Accreditation for Marriage and Family Therapy Education. 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 seminar introduces students to the leading schools of family therapy—structural, strategic, transgenerational, narrative, etc.—as well as introducing students to Transitional Family Therapy.

PSI 560. Narrative Approaches to Psychotherapy
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.

PSI 564. Transitional Family Therapy
Transitional Family Therapy is a model developed at Rochester that blends here-and-now, transgenerational, and ecosystemic factors in the practice of family therapy. The course is an in-depth examination of the theory and practice of this approach.

Clinical Practice

PSI 541. Introduction to the Clinical Practice of 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 Practice I and II
These courses prepare students specifically for Clinical Practicum.

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 545. Life-Span Development and Intergenerational Patterns
This course teaches developmental issues across the life span and relates these developments to intergenerational patterns as well as family of origin theory and its role in clinical practice.

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.

Individual Development and Family Relations

PSI 570. Gender, Race, and Culture in Family Therapy
Students learn the role that gender, race, ethnicity, sexual preference, and cultural beliefs play in family life and clinical practice.

PSI 574. Child-Focused Family Therapy
This course teaches students to work with families in which the primary focus is child behavioral difficulties and parenting issues. Students earn both theoretical and clinical skills in dealing with problems that arise at different developmental stages.

Professional Identity and Ethics

PSI 548. Family Therapy-Ethics and Professional Practice
Students 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. In addition, the course focuses on key aspects of professional practice.
Research

PSI 572. Family Therapy Research
Students are introduced to quantitative and qualitative methods in family therapy research and learn to critically examine and use research findings in clinical practice.

PSI 584/586. Master's Project
All master's degree students complete this project, which 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.

Electives

PSI 426. Families Coping with Long-Term Mental Illness
Students learn how to diagnose and treat patients and families dealing with persistent mental illnesses, such as schizophrenia, bipolar disorder, and major depression.

PSI 428. Group Psychotherapy
Students learn about group theory and dynamics and also have the experience of functioning within a small group.

PSI 492. Medical Family Therapy Institute
This course is based on a week-long, intensive lecture that 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 580. Death and Mourning
One of the most influential forces in family life is loss in its many forms. This course enables students to understand loss and mourning as it is shaped by current family factors as well as transgenerational influences.

PSI 582. Families and Violence
A startling percentage of families experience violence on a regular basis. Students learn how to work with issues of violence when working with families, couples, and individuals.

PSI 587. Clinical Practicum (minimum of two semesters)
Clinical Practicum provides students with the opportunity to practice independently in one of several psychiatric mental health and health care settings in the community. Each student meets weekly with an AAMFT-approved supervisor or supervisor candidate to review videotape and further develop conceptual and clinical skills.

Microbiology and Immunology

Research Associate Professors Livingstone, Quataert
Research Assistant Professors Bousee, Bradel-Tretheway, Fan, Robert, Sheng, Xu
Scientist Holtfreter
Professors Emeriti Abraham, Allen, Bowen, Christensen, Cohen, Hare, W. Iglewski, Maniloff, Silver

* Primary appointment in another department.
† Part-time.
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 Ph.D. 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 Ph.D. 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 Ph.D. in microbiology and immunology. Particulars about the Ph.D. programs in the various tracks are available from the departmental office on request.

The M.S. degree (Plan A) is intended for those whose career goals are in research. Individuals whose primary interest is in seeking subsequent admission to medical school are not encouraged to apply. 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 Ph.D. 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 M.S. 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 Ph.D. 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.

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, and mode of action. 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.

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. Ph.D. 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. (Spring, alternate years)
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 seminar program is presented each semester; continuous registration is required of all Ph.D. students in the Department of Microbiology and Immunology. Seminars are held once a week and are conducted by graduate students. First- and second-year Ph.D. candidates present a topic from the current literature. Senior graduate students present a seminar on their research progress. (Fall and Spring)

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, Ph.D. students are expected to enroll for three rotations.

509. Scientific Communications
Credit—two hours

This 12-session course provides basic instruction in oral and written communication skills for microbiology and immunology graduate students. The course offers a brief introduction to scientific logic and the construction and experimental testing of scientific hypotheses. This grounding is then used as a platform from which to provide specific instruction in presentation skills, with an emphasis on practical, hands-on instruction and experience in both written and oral communication. Students are required to complete assigned readings, to write a short research paper (1,000 words), and to prepare and deliver a short oral presentation (10 minutes). For most students, it is expected that the research paper and oral presentation be based on data from any one of their three research rotations; additional flexibility is permitted (if needed) to best meet the learning objectives of this communication course. (Fall)

514. Pathogenic Mechanism Seminar
Credit—one hour

Seminar offered concurrently with MBI 414. Required for Ph.D. students. (Spring, alternate years)

515. Advanced Immunology
Credit—four hours

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)

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 Ph.D. 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 Ph.D. microbiology students. This course involves the discussion of the primary literature to explore the molecular mechanisms used by various microbes to regulate expression of products involved in 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 covers a particular aspect of immunology in depth with an emphasis on critical reading of original journal articles. Two to four papers are read each week with oral presentation by the students. (Fall)

580. Immunology Journal Club and Research-in-Progress Seminar  
Prerequisite: MBI 473.  
Consists of two parts: Part I is the Immunology Journal Club (meets one hour per week), in which students read and discuss recent papers from the immunology literature; Part II consists of attendance at the weekly one-hour Immunology Research-in-Progress seminar series. (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, and viral transcription regulation. Students present reviews of the literature and write critiques. (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. Ph.D. Research  
Credit to be arranged  
Research may be undertaken in virology, general medical microbiology, animal parasitology, immunochemistry, genetics, physiology, bacterial cytology, and cellular immunology.
Neurobiology and Anatomy


Assistant Professors K. Davis, *Gan, G. Gdowski, M. Gdowski, *Huxlin, Kornack, Majewska, Pinto, Romanski, Seidman

Research Associate Professors *Wood, *Walton

Research Assistant Professors Hurley, Quessy

Professors Emeriti DelCerro, Thomas

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 35 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/nana).

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 Graduate Program in Neurobiology and Anatomy, commitments include extensive instructional and leadership roles in the Interdepartmental Graduate Program in Neuroscience, and participation 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 M.D./Ph.D. program, we offer a new Academic Honors Program in Medical Neurobiology (M.D./M.S.), which adds an additional year of study, research and teaching experience to the medical curriculum, culminating in an M.S. degree in neurobiology and anatomy along with the M.D. degree upon graduation.

The Ph.D. program in neurobiology and anatomy is particularly well suited to students in the University’s M.D./Ph.D. program and to Ph.D. 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/clinical attributes of neural science.

The curriculum shares a core first year with the Interdepartmental Graduate Program in Neuroscience to instill a firm foundation in broad aspects of neurobiology. In the second year, a rare

* Primary appointment in another department.
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.

491. M.S. Reading
495. M.S. Research
501. Histology
Credit—variable

This course in microscopic anatomy emphasizes correlating structure with function. The course includes hands-on laboratory sessions during which fixed specimens, prepared by a variety of methods, are examined with a microscope. Information derived by newer techniques (scanning electron microscopy, transmission electron microscopy, immuno-cytochemistry, stereology, autoradiography, etc.) are introduced where appropriate. The course uses a variety of teaching formats: lecture, small-group conferences, clinical correlation exercises, and clinical case-based sessions. Examinations include both written and laboratory practical parts. (Spring)

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 will include 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 dissections 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 lec-
tecture 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—six 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.
Credit—four hours
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)

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 transductions—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)

524. Stem Cells of the CNS in Development and Disease  
Prerequisite: ANA 512.  
Credit—three hours  
This course covers the most recent and relevant advances in the field of stem cell biology with a focus on the CNS. In the first series of lectures, the basic question—what makes a cell a stem cell?—is addressed. The differentiation potential of stem cells in vitro and in vivo are discussed along with mechanisms of fate determination and the control of differentiation versus proliferation. Students learn the basic aspects of stem cell biology and the role of stem cells in disease paradigms. Topics include the involvement of stem cells in pathological conditions of malnutrition and carcinogenesis and the potential use of stem cells for transplantation therapies. (Fall)

525. Mind, Brain, and Behavior  
Credit—three 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 you to 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—twelve 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, problemsolving 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. Ph.D. Research  
Opportunity is afforded for qualified students to undertake research under the direction of members of the staff.

Neuroscience

Professors Aslin,1 Bidlack,2 Cohen,1 Coleman,5 Dewhurst,3 Dory,5 Duffy,5 Dworkin,6 Federoff,8 Frisina,7 Gelbard,9 Goldman,8 Gross,9 Haber,9 Hayhoe,1 Ison,1 Joseph,11 Kellogg,1 Knill,1 Makous,1 Merigan,9 Moynihan,12 Nedergaard,11 Newport,9 Noble,17 E. Nordeen,1 K. Nordeen,1 Ogihara,13 Paige,1 Pasternak,2 Pinkert,14 Powers,14 Rodier,10 Schieber,8 Sheu,1 Shrager,5 Tank,2 Williams,1 Zlokovic11

Associate Professors Bavelier,1 Blair,7 Dickerson,5 Dirksen,2 Freedman (Cluster Director),3 Freeman (IGPN Program Director),2 Fudge,12 Gan,9 Giger,8 Luebke,15 Mayer-Proschel,17 Mink,8 O’Banion,5 O’Neill,9 Olschowka (NBA Program Director),1 Pearce,16 Perls,12 Piekut,7 Pouget,7 Ringo,2 Segal,8 Stevens,1 Thornton,9 Weliky1

Assistant Professors Bowers,3 Davis,15 G. Gdowski,3 M. Gdowski,7 Helmreich,12 Huxlin,7 Kornack,5 Kyrkanides,16 Lee,1 Magirwar,1 Majewska,3 Opanashuk,4 Parfit,12 Pinto,4 Portman,12 Rempe,8 Romanski,5 Seidman,5 Sieu4

Research Associate Professors Loy,6 Walton,11 Wood,10 Zarcone4

Research Assistant Professors Callahan,14 Lu,8 Madden,12 Maguire-Zeiss8
The Graduate Program in Neuroscience at the University of Rochester is designed to provide the interdisciplinary training needed to study the nervous system at many levels of analysis. This is accomplished with the aid of over 80 faculty members in over 20 different departments from both the School of Medicine and Dentistry and the College, representing an extensive community of scientists across a single unified campus. This unique program offers its students the opportunity to study a wide range of modern neuroscience disciplines organized as specific programmatic themes. This organization provides a convenient matrix by which both faculty interests and curriculum/course offerings can be effectively sparsed. The five themes, including Sensory and Motor Systems, Cognitive and Behavioral Neuroscience, Molecular and Cell Signaling, Development and Aging, and Neurobiology of Disease, bind the program into areas of expertise and research focus.

The Graduate Program in Neuroscience at the University of Rochester attracts students from a variety of scientific backgrounds. We engage our students in research early in their career and provide them with a rigorous core curriculum in cellular and systems neuroscience that builds a solid foundation for more advanced, specialized coursework relevant to their individual interests.

During the first year of study, students attain an understanding of cellular and molecular neurobiology and acquire a strong background in systems neuroscience. Coursework focuses on cell anatomy, molecular biology, chemistry, and electrophysiology presented in the context of neuronal signaling and transduction, neurotransmission, and neuronal development and plasticity. The anatomy, physiology, and chemistry of neuronal systems are examined as they relate to functions as diverse as movement, sensation and perception, cognition, and homeostasis. An understanding of neuropathology and neurological disease at both the cellular and systems levels is also emphasized.

Laboratory rotations are an important component of the neuroscience students’ first year of study. They are intended to both familiarize students with a range of research topics and techniques and facilitate the students’ choice of a dissertation laboratory following the first year of study. The sequence of three separate rotations is planned respectively in consultation with a faculty advisory group. During each rotation, students conduct a research project under the guidance of a faculty member of their choice. Students formally present their work to the faculty and their peers in a biannual lab rotation presentation session.

Coursework in the second year is intended to provide students with expertise in their chosen area of research. In consultation with their research advisor, students typically choose two or three neuroscience course electives that define a theme tailored to their individual area of specialization. The rich variety of upper-level courses and interest-specific tutorials offered by the diverse faculty comprising the Graduate Program in Neuroscience insures that students have the flexibility to develop a curriculum that will both augment their research effort and broaden their view of neuroscience.

Critical thinking and practical consideration of experimentation, data analysis, and funding issues are addressed by coursework and seminars in statistics, experimental design, biomedical science ethics, and grant writing and review. A regular journal club attended by all first- and second-year students focuses on new findings in the neuroscience literature and provides additional experience.

Neuroscience faculty primary appointments are in the following departments as annotated:

1. Department of Brain and Cognitive Sciences,
2. Department of Pharmacology and Physiology,
3. Department of Microbiology and Immunology,
4. Department of Environmental Medicine,
5. Department of Neurobiology and Anatomy,
6. Department of Anesthesiology,
7. Department of Otolaryngology,
8. Department of Neurology,
9. Department of Ophthalmology,
10. Obstetrics and Gynecology,
11. Department of Neurosurgery,
12. Department of Psychiatry,
13. Department of Computer Science,
14. Department of Pathology and Laboratory Medicine,
15. Department of Biomedical Engineering,
16. Department of Dentistry,
17. Department of Biomedical Genetics,
18. Department of Biochemistry and Biophysics.
in critical thinking and experimental design. Students learn important teaching and speaking skills by completion of a one-semester teaching assistantship and presentation of their research at regular student seminars. Students are also involved in organizing the weekly Neuroscience Colloquium that brings noted speakers to the University. Additional seminar platforms are provided through series sponsored by the participating departments and centers.

Upon completion of the neuroscience core curriculum, students in the Graduate Program in Neuroscience have the option of pursuing one of five degrees; these degrees include a Ph.D. in neuroscience via the Interdepartmental Graduate Program in Neuroscience and degrees in neurobiology and anatomy, brain and cognitive sciences, pharmacology and physiology, or biomedical engineering. The latter three programs also admit students directly into their own graduate programs.

508. Neural Plasticity in Learning and Development
Credit—three hours

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. Readings are drawn from review and primary research articles. Students write a critique of a relevant journal article as well as a critical overview of a research topic germane to the course. This is a course designed for graduate students and undergraduates who have a background in the neurosciences.

510. History of Neuroscience
Credit—one hour

This series of lectures and discussions covers various aspects of the historical development of our knowledge about the nervous system and the evolution of modern neural science. Some of the topics covered from this standpoint are the brain as mind, cortical localization, neuron doctrine, development of clinical neurology, development of electrophysiology, connection theory of higher function, memory and dementia, frontal lobe function, corpus callosum function, and others. This course is open to graduate students, medical students, residents and interested members of the faculty. (Fall, odd numbered years)

512. Cellular Neuroscience
Credit—six hours


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, even years)

530. Neural Basis of Learning, Memory, and Higher Function
Prerequisite: NSC 512 or equivalent; or permission of instructor.
Credit—three hours

A part lecture, part discussion course covering the physiologic bases of learning and memory. Topics include types of memory, evidence of memory in single unit responses, computational approaches, habituation, conditioned reflexes, electrophysiologic indices, neuroanatomy of amnesia, interhemispheric relations, and clinical amnesia. Advanced undergraduates may elect this course with approval of course director. (Fall semester, odd years)
531. Integrative and Systems Neuroscience  
Prerequisites: NSC 512, NSC 201/BCS 240  
or equivalent introductory neuroscience course.  
Undergraduate students with permission from instuctor only.  
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.

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. In addition, students devote time to the preparation of teaching aids such as videotapes and slides.

590. Lab Rotations in Neuroscience  
Credit—to be arranged  
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.

592. Neuroscience Journal Club  
Credit—one hour  
A seminar/reading course 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.

595. Ph.D. Research  
Credit to be arranged

Center for Oral Biology

Professors *Begenisich, *Marquis, Melvin (Director), *Shuttleworth  
Assistant Professors Haas, Hsu  
Research Assistant Professors Bedi, Gonzaléz-Begné, Hagen, Lan, Nakamoto, Ovitt, Romanenko, Srivastava  
Professor Emeritus Bowen

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.

* Primary appointment in another department
Studies leading to the M.S. degree with a major in dental science typically cover two calendar years and a total of at least 30 hours of credit consisting of 18 for coursework and 12 for research. Prerequisites for acceptance in this program are the D.D.S., D.M.D. degree, or equivalent. Predoctoral 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 Center for Oral Biology. In addition, all candidates must choose a particular area in the basic 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 results of this work must be presented in a thesis acceptable to the candidate’s committee (Plan A, thesis only). Fellowship stipends sufficient to meet living costs are available to selected students on a competitive basis.

University grants-in-aid and grants from industrial sources enable the Center for Oral Biology to offer fellowships to dental school graduates and others of unusual ability and promise who desire special training in disciplines including anatomy, biochemistry, biophysics, dental science, genetics, microbiology, molecular biology, neuroscience, pathology, pharmacology, physiology, and toxicology in order to equip themselves for careers in teaching and research.

The Training Program in Oral Infectious Diseases provides support for pre- and postdoctoral (D.D.S. or Ph.D.) fellows to receive training for three years. The objective of the program is to prepare creative, imaginative, and highly skilled professionals in the fields of oral microbiology and immunology.

The Oral Cellular and Molecular Biology Program trains individuals committed to careers in oral science in the approaches of cellular and molecular biology. Training is provided in these areas to the Ph.D. level for dentists and predoctoral candidates who have a commitment to careers in oral science.

414. Mechanisms of Microbial Pathogenesis
Prerequisites: 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 first semester is devoted to a systematic review of recent significant research developments in one of the basic sciences fundamental to dentistry. In the second semester the dental fellows report on original research. Required of all graduate students in dental research 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)
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. (Spring)

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 its clinical application. (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

Research Assistant Professors *A. Friedman, *C. Proschel, J. Reeder

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 10 departments. This provides diverse education and research experiences and thesis opportunities for the student. The

* Primary appointment in another department
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.

Students enter the graduate program in pathology after completion of their first year of study in one of the graduate research clusters in the Graduate Education in the Biomedical Sciences (GEBS) program. For those who enter the program through the Pathways of Human Disease Cluster, the first year 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, students request admission to the graduate program in pathology. After approval by the Steering Committee of the Graduate Program, the students follow a disease-oriented curriculum in elective studies and in advanced coursework during the second year. Students usually designate a thesis advisor at the time of admission. Admission requirements include successful completion of course requirements, approval of the program director, and a desire to pursue thesis research that has a relationship to human health and disease.

The faculty of the graduate program in pathology represent at least 10 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 introduces students to the diverse experimental and intellectual approaches for studying disease processes, in a seminar format. Investigators from both outside and within the University present the current view of pathogenesis for the disease of their specialty and discuss classical and molecular methods to probe for disease mechanisms. Students are also required to present a yearly 60- or 30-minute research seminar based on their own research studies. (Fall and Spring)

507. Cancer Biology
Credit—three hours
The course is intended primarily for students interested in cancer research. Cancer biology is introduced through lectures on the history of early scientific inquiry as a foundation for understanding the current state of cancer research. The genetic basis of cancer is emphasized in familial cancer syndromes, acquired somatic mutations, and micro-evolution of neoplasia. Background is provided on normal cellular functions, such as cell cycle control and signal transduction, that go awry in cancer. Epidemiology, environmental carcinogenesis, the impact of tobacco use, and chemoprevention are thoroughly explored. The remainder of the course focuses on specific cancer sites with lectures by experts on various cancers with goals of understanding the human impact of the disease and identifying common themes as well as distinctive characteristics. Grades are based on two exams and a written essay that is also presented to the class. Lecture topics include historical perspectives, epidemiology, tumor genetics, hereditary cancers/familial cancer syndromes, cancer and the cell cycle, cooperative oncogenes, viral carcinogenesis, nuclear oncogenes, telomerase, chemical carcinogenesis, oncology/radiation, oncology/chemotherapy, smoking and cancer, chemoprevention, colon cancer, leukemia, lymphoma, hepatocellular carcinogenesis, breast cancer, pediatric cancer, prostate cancer, bladder cancer, central nervous system tumors, cervical cancer, and skin cancer. 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. Three weekly 60-minute lectures. (Spring)

509/510. Pathways of Human Disease I and II
Credit—four hours

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. Additionally, they obtain an understanding of the current applications and limitations of modern diagnostic medicine and the importance of basic translational research. The course is divided into six modules, three per semester. Each module uses two organ systems (e.g., the cardiovascular system, the musculoskeletal system, the liver, the respiratory system, etc.) as the basis for an in-depth discussion of one major theme of human pathobiology. 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 analytical methodologies. (Fall I, Spring II)

520. Frontiers in Mitochondrial Medicine
Prerequisite: permission of the instructor. 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 and 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. Mitochondria are uniquely positioned to integrate a host of cellular information and then influence function in every cell type. In “Frontiers in Mitochondrial Medicine,” a foundation for understanding normal mitochondrial biology is established and then the importance of mitochondria in disease is explored—from neurodegeneration to cancer. This elective course meets weekly and is designed for graduate students who have an interest in mitochondrial biology. It is also open to upper-division undergraduate students, medical students, residents, staff, and interested members of the faculty. (Spring, odd years)

593. Molecular Mechanisms of Human Disease
Prerequisite: permission of the instructor. In addition, previous completion of IND 410, 409, and 408 classes is required. Credit—four hours

The bridging between biological research and medicine requires an understanding of biological tools to address cellular and molecular aspects of pathology. How can we use cell and molecular biology, genetics, and transgenic technologies to address human diseases? This course is a translational medicine-oriented presentation of current knowledge of the underlying cellular processes and molecular events that cause human disease. Using the lecture format, faculty define a path from state-of-the-art research tools to discuss the background, etiology, molecular mechanisms, and therapeutic interventions for a selected panel of human diseases. A significant emphasis is placed on defining the limits of the current understanding of the disease processes and strategies for innovative experimentation that should lead to breakthrough discoveries and cures. Students are assigned a paper of interest that they collaboratively present and discuss with their peers. Every student is required to write a 250-word summary of each assigned paper. Midterm and final exams. (Fall)

595. Ph.D. Research
Credit to be arranged

Ph.D. research is done under the direction of a faculty member of the Medical Center with the approval of the graduate program in pathology.
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. Pharmacology and Physiology: A Disease-Based Approach I

**Credit—four hours**

Course is designed to provide a foundation for students interested in how cells, organs, and organisms work; the mechanisms underlying some human diseases; and how therapeutic drugs target these disease states. First semester of this two-semester course covers (1) Basic Pharmacological Principles at a molecular and cellular level including drug binding, metabolism, and pharmacokinetics; (2) Neuromuscular Disorders including the physiology and pathology of nerves and muscles; (3) Drugs of Abuse and Mood Disorders, including basic mechanisms of addiction and specific neurological and psychiatric diseases such as depression, schizophrenia, epilepsy, and Parkinsonism and drug treatments for these diseases; (4) The Pharmacology and Physiology of Cardiac Electrical Activity including the origin of the electrical cardiogram (ECG), the mechanism of cardiac arrhythmias, and the drugs to treat them. (Fall).

### 404. Pharmacology and Physiology: A Disease-Based Approach II

**Prerequisite:** PHP 403 or permission of course director.

**Credit—four hours**

This course continues the study of human physiology and therapeutic drug mechanisms
begun in PHP 403. A major emphasis of this semester is an in-depth study of the various issues surrounding heart failure. These include the basics of cardiovascular and renal biology. Hypertension and heart failure are described as well as the various cardioactive drugs for their treatment. The physiological mechanisms relevant to diabetes, cystic fibrosis, and asthma are included as well as the therapies for treating these diseases. Finally, the principles of cardiovascular, respiratory, renal, and endocrine physiology come together to provide an understanding of the response of the human body to the natural stress of exercise. (Spring).

440. Topics in Vascular Biology
Prerequisite: graduate physiology recommended and permission of instructor.
Credit—four 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. (Spring, odd years)

447. Signal Transduction
Credit—four hours

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. M.S. Reading
Credit to be arranged

495. M.S. Research
Credit to be arranged

502. Seminar
Credit—one hour each term

General topics presented by students and staff members. Organized surveys of selected fields may be presented upon request.

520. Frontiers in Mitochondrial Medicine
Prerequisite: permission of the instructor.
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. Mitochondria are uniquely positioned to integrate a host of cellular information and then influence function in every cell type. In Frontiers in Mitochondrial Medicine, a foundation for understanding normal mitochondrial biology is established and then the importance of mitochondria in disease is explored—from neurodegeneration to cancer. This elective course meets weekly and is designed for graduate students who have an interest in mitochondrial biology. It is also open to upper-division undergraduate students, medical students, residents, staff, and interested members of the faculty. (Spring)

530. Advanced Topics in Pharmacology
Credit—two hours

This is an elective course designed as a small group class (4–12 students) and focuses on six topics related to diseases and their current therapeutic modalities. The didactic goals for each topic is to understand: (1) the basic anatomy, histology, and physiology of the organ system; (2) alterations in physiological, cellular, and/or biochemical mechanisms associated with a disease; (3) current therapies, their mechanisms of actions, and limitations; and (4) potential targets for future therapies. Each topic is presented over two sessions by two to four students working as a group, and in consultation with the topic instructor. Besides a presentation describing key results and putting forward the authors “take home message,” students discuss the appropriateness of the model(s) used, pitfalls or limitations of the methods, alternative methods or approaches not used, how the work advances the field, and potential directions for future research. Students learn the basics of additional physiological systems and current therapeutic approaches to address corresponding health-related issues and also develop essential skills not readily obtained in lecture-based courses.
550. Ion Channels and Disease
Credit—two hours

Advances in molecular biology, cellular physiology, and structural biology, coupled with the recent progress in sequencing of the human genome, have revealed an increasing number of human and animal diseases that arise from defects in ion channel function. Many of these diseases, caused by mutations in genes encoding ion channel proteins, are now referred to as channelopathies. This course focuses on the function of ion channels in normal physiological processes in the brain, skeletal, and cardiac muscle and how these functions are altered in certain channelopathies. These advances are examined through readings of the original literature integrated with didactic material where useful. Topics include the biophysical basis of excitation in nerve and muscle, excitation-contraction coupling, synaptic plasticity, and other topical subjects. Special emphasis is placed on the molecular basis of important ion channel diseases and other pathologies involving ion channels including genetic defects that lead to cardiac arrhythmias, skeletal muscle myotonias and paralyses, and epilepsy. (Spring)

552. Readings in Systems Physiology
Credit to be arranged

This readings course includes detailed critical discussion of original scientific publications. Readings are chosen to illustrate current topics in cell and molecular physiology as they relate to the integrated function of organ systems in health and disease.

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.

Toxicology

Professor Ballatori (Program Director)

The core faculty involved in the Toxicology Graduate Training Program are drawn predominantly, but not exclusively, from the Department of Environmental Medicine. These are listed below. However, research projects dealing with significant toxicological issues may be performed with other faculty within the Medical Center.


Associate Professors Chess, Frampton, R. S. Freeman, Markowitz, McCabe, O'Reilly, Pearce, Pryhuber, Schwarz, Stevens

Assistant Professors Mayer-Prochel, Opanashuk, R. Pierce, A. Rahman, I. Rahman, Sime, Tieu, Topham, Villalobos

By its nature toxicology is highly interdisciplinary. It combines the knowledge base and approaches of such fields as physiology, pharmacology, psychology, biochemistry, and molecular biology to address 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. On average, about 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 vision, indices of behavior, motor activity, discriminative control and learning, neuroimmune interactions, as well as effects on neurotransmitters and their receptors. Nanoparticles, heavy metals (e.g., lead, mercury), organic solvents (toluene, carbon disulfide), nerve poisons (acrylamide), abused drugs (cocaine, d-amphetamine), and aversive airborne substances (ozone) are among the agents that have been studied.

Pulmonary toxicology. Physiological and biochemical studies of the lung are made in order to discover how inhaled aerosols cause injury. Mechanisms of deposition and clearance of inhaled particles are studied in both laboratory animals and man. Cellular and molecular aspects of chronic lung injury (e.g., pulmonary fibrosis, lung cancer, and immunological aspects) are investigated in animals and extrapolation models then developed in order to predict effects in humans and, perhaps, develop protective measures.

Osteotoxicology. Investigations are conducted of the molecular and cellular biology of the skeletal system and its development.

Molecular modifiers of toxicity. Some faculty in this group attempt to identify specific molecular receptors underlying the selective action of poisons, the location of these receptors 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 estrogen and 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) receptors. Other faculty are studying the mechanisms by which oncogenes transform cells, DNA-repair mechanisms, bioactivation processes, the role of glutathione and biotransformation in the defense against toxicants, the role of heme oxygenase in cellular regulation, mRNA regulation, 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 environmental chemicals on lymphocyte development and the regulation of antibody-producing lymphocytes by prostaglandins.

Reproductive and developmental toxicology. Current investigations focus on a range of problems associated with oogenesis, implantation, placental function, developmental immunology, CNS development, growth, teratogenesis and transplacental carcinogenesis. A particular interest has been establishing the mechanisms of action for metals (cadmium, lead, methylmercury, tellurium) 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD), retinoids, steroids, and drugs used for the treatment of HIV infection during reproduction and development.

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 Ph.D.

493. Special Topics in Toxicology—Toxicology in the Workplace Environment
Credit—two hours

This course focuses on toxicologic effects of widely used workplace substances. The course has a seminar format. Students choose an area of interest (usually a workplace toxin or category of toxins), and a faculty member to work with who has expertise in the area. The student then prepares and presents a seminar on this topic to the other students in the course. (Fall, even years)
493. Special Topics in Toxicology—Immunotoxicology  
Credit—one hour  
Selected topics relevant to current issues and problems in immunotoxicology are covered. The course draws on recent peer-reviewed publications and/or reviews that are discussed and critiqued by the participants in a colloquium-style format. (Spring, 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 which requires presentations from recent literature considering the effects of lung-directed toxic agents on pulmonary anatomy, physiology, and biochemistry. (Spring, even years)

591. Ph.D. Reading Course  
Credit to be arranged

592. Current Topics in Immunotoxicology  
Credit—one hour  
Selected topics relevant to current issues and problems in immunotoxicology are covered. The course draws on recent peer-reviewed publications and/or reviews that are discussed and critiqued by the participants in a colloquium-style format. (Spring, odd years)

593. Forensic Toxicology  
Prerequisite: permission of the instructor.  
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)

594. Molecular Toxicology  
Credit—one hour  
This course includes the review of recent and significant research publications describing approaches used to discern fundamental principles of cellular and tissue response to environmental stimuli. A thorough knowledge of molecular biology is not essential for participation in this class, although an understanding of basic principles in molecular genetics is helpful. (Fall, even years)

595. Ph.D. Research in Toxicology  
Credit to be arranged
School of Nursing

ADMINISTRATIVE OFFICERS

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Lynn Nichols, M.S.N., R.N. (Pennsylvania) . . . Research Associate
Elizabeth Walker-Kellogg, Ph.D. (Rochester) . . . 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 graduate program is fully accredited by the National League for Nursing Accrediting Commission, NLNAC, 61 Broadway, 33rd Floor, New York, New York 10006, (212) 363-5555, extension 153.
DOCTORAL PROGRAM

The Ph.D. in nursing program, established in 1978, prepares nurses for leadership positions in teaching, research, nursing practice, and the health care system. Graduates of the program hold such positions throughout the United States and internationally. Nurses are needed to assume faculty positions in schools of nursing, to engage in innovative models of care through faculty practice, to conduct research for the improvement of nursing and health care, and to formulate health care policy. These roles require the ability to (1) identify the critical questions related to nursing and health care, (2) engage in research concerning behavior in health and illness, and the complex phenomena of nursing and health care delivery, (3) use research findings for the furtherance of evidence-based practice, and (4) formulate policy. Four components of the doctoral program address the development of these skills: (1) theory development and research methods courses, (2) support (cognate) courses, (3) clinically focused nursing 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 Ph.D. 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 Ph.D. qualifying examination is given when the first year of doctoral coursework is completed. The dissertation proposal defense constitutes a second qualifying examination and the milestone for advancement to candidacy and must be completed at least six months prior to final defense of the dissertation. The Ph.D. is awarded following the successful defense of a written dissertation. Sample program plans are available on request.

PH.D. ADMISSION REQUIREMENTS

1. Master of Science degree in nursing from an accredited program.
2. Cumulative GPA of 3.0 for undergraduate work and 3.5 for graduate work.
3. Completed Ph.D. application.
5. Competitive scores on the Graduate Record Examination (general test only).
6. Statistics course with a grade of “B” or higher.
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 academicians 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.
M.S. AND PH.D. DUAL DEGREE PROGRAMS

Seven new programs combining the M.S. and Ph.D. in nursing were approved by the State of New York in September 2000. The seven programs are based on the existing M.S. and Ph.D. programs in the School of Nursing. Students are admitted directly to the M.S./Ph.D. program of their choice, and completion of the Ph.D. is accelerated by using a full calendar year program plan, replacing M.S. level research courses with Ph.D. research courses, and allowing Ph.D. cognate credit for a limited number of courses in the master’s program. The program design integrates doctoral-level courses with master’s-level courses from the beginning, rather than offering the programs sequentially. However, those whose personal plans change may exit with a terminal master’s degree following completion of all master’s coursework.

These combined programs are designed to attract academically and clinically able students who (1) are interested in practicing in one of seven advanced practice nursing roles (adult nurse practitioner, acute care nurse practitioner, family nurse practitioner, gerontological nurse practitioner, pediatric nurse practitioner, pediatric/neonatal nurse practitioner, or psychiatric mental health nurse practitioner); (2) are interested in assuming faculty positions in advanced practice educational programs; and (3) who desire to conduct research to develop the science that underpins nursing practice. 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 total number of program credits required 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.

M.S./PH.D. 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. Declare master’s degree specialty area as part of the admissions process
4. Nursing practice experience as required by the chosen specialty area prior to matriculation
5. Cumulative grade point average of 3.0 preferred for undergraduate work
6. Statistics course with grade of “B” or above
7. Completed M.S./Ph.D. 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 academicians.
13. Favorable interviews with two SON faculty members delineating goals and interests for combining a clinical master’s degree with the Ph.D. degree

All admission materials for the Ph.D. and M.S./Ph.D. combined programs should be submitted to the Office of Student Affairs, School of Nursing.

Beyond the general requirements, during the admissions process strong consideration is given to the match of student research interests with faculty programs of research. Three general areas of faculty research in vulnerable youth, gerontology, and acute care are currently supported by centers for research in the School of Nursing. They are the Center for High Risk Children and Youth and the Center for Clinical Research on Aging.

After all application materials are received, personal interviews with faculty members, required as part of the admissions process, are arranged by the Office of Student Affairs, School of Nursing, based on a match of interests. The interviews may be conducted by telephone if necessary.

Both full-time and part-time admissions are considered. Students admitted to the full-time Ph.D. program usually require a minimum of three and one-half years to complete the program. Minimum completion time for the M.S./Ph.D. combined programs is four and one-half years of full-time study.

FINANCIAL ASSISTANCE

Full tuition scholarships, up to 60 credits, may be granted to full-time doctoral students, and for 60 credits of Ph.D.-level coursework in the M.S./Ph.D. combined programs depending on availability of funds. Some School of Nursing stipend support may be available for two years of full-time doctoral 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 Center for Research and Evidence-Based Practice in the School of Nursing.

MASTER OF SCIENCE PROGRAM

Graduate study at the master’s level in the School of Nursing integrates nursing practice, education, and research. It is designed so that the professional nurse can respond to the challenge of unresolved problems in nursing and in the health care system by increased understanding and by contributing to the body of nursing knowledge through practice, teaching, and scientific inquiry.

The areas of concentration of the master’s program in nursing provide an opportunity for depth and breadth of preparation in nursing specialty areas, and for role development as advanced practitioner, leader, and researcher. While each clinical nursing area has its special requirements, there are common substantive areas of study in the nursing core and in research methods. Opportunities exist for elective courses. All areas of concentration require completion of between 30 and 72 credits in addition to 560–1,064 hours of supervised clinical experience.
for the degree. The Leadership Program has required projects in place of precepted nursing clinicals. 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. The School of Nursing reserves the right to cancel courses for which there is insufficient enrollment.

ACCELERATED MASTER’S PROGRAM FOR NON-NURSES

This is a program for accelerated entry into nursing for second-degree students (non-nurses with a baccalaureate degree in another discipline). The program is an accelerated generalist baccalaureate degree in nursing to be completed in 12 calendar months of full-time study. At the successful completion of the generalist curriculum, the B.S. is awarded and students are eligible for registered nurse licensing examinations (NCLEX). Following completion of the generalist curriculum, students move into one of the M.S. nurse practitioner specialty programs. These programs can be completed in an additional two years of full-time study or can be undertaken on a part-time basis. At the successful completion of the specialist curriculum, students are awarded the M.S. degree and are eligible for nurse practitioner licensing and credentialing.

ACCELERATED B.S. AND M.S. FOR REGISTERED NURSES

This is an accelerated bachelor and master of science degree program (R.N. to B.S. to M.S. 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 master’s degree as their educational goal and who possess the motivation and potential to complete graduate studies. Sixty-four arts and sciences credits may be applied toward the R.N. to B.S. to M.S. program. This may result in the applicant needing to take only two or three undergraduate courses in addition to the master’s program. For information on this program, contact the Office of Student Affairs, School of Nursing, (585) 275-2375.

ADMISSIONS

Professional nurses who have an associate’s degree or diploma with a major in nursing are eligible to apply for admission to the R.N. to B.S. to M.S. program for full-time or part-time study. Professional nurses who have a baccalaureate degree with a major in nursing are eligible to apply for admission to full- or part-time study in the master’s program. Non-nurses who have a baccalaureate degree in another discipline are eligible to apply for admission to the Accelerated Master’s Program.

Office of Student Affairs
University of Rochester
School of Nursing
Box SON
601 Elmwood Avenue
Rochester, NY 14642-8404
(585) 275-2375
Admission Requirements

An introductory course in statistics is prerequisite for admission to the master’s program.

Applicants 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:
1. a completed application for admission
2. a professional statement, resumé, and writing sample
3. two favorable references which address professional and/or academic ability: one master’s prepared nurse (e.g., nursing faculty member, clinical nurse specialist, or nurse manager) preferred and/or nursing supervisor
4. 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 updating. A current license to practice nursing must be on file with the School of Nursing.

FINANCIAL ASSISTANCE

Depending on availability, full-time master’s students may receive partial tuition scholarships made possible by the federal program, “Advanced Education Nurse Traineeship Grant” awarded by the Department of Health and Human Services, U.S. Public Health Service. Interest in fellowships or scholarships should be indicated on the general application form at the time of application for admission. Employees of Strong Memorial Hospital are eligible for tuition benefits after requirements for length of employment are met. Other opportunities, e.g., National Health Service Corporation and foundation grants, may be available.

Several loan programs are administered through the University’s Office of Admissions and Financial Aid.

SPECIALTY AREAS

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 researcehable questions are developed. The specialty offers students opportunities to study in a variety of acute and chronic care settings. Critical appraisal of how advanced practitioners 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 certification as nurse practitioners and American Nurses Association (ANA) certification as acute care nurse practitioners.

**Care of Children and Families—Pediatric Nurse Practitioner and 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 and clinical nurse specialist 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 nurse practitioners.

**Adult, Family, and Gerontological Nurse Practitioners**

The graduate specialties in primary care nursing prepare the nurse to function 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 ANA and New York State certification as adult, family, or gerontological nurse practitioners and are uniquely prepared to provide primary care to populations with unmet needs, particularly the socially and economically impoverished, the chronically ill, and those with psychosocial illness.

**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 psychiatric/mental health nursing. Graduates are eligible for New York State certification as psychiatric/mental health nurse practitioners and ANA certification when post-graduate requirements are met.

**Leadership in Health Care**

The M.S. degree in Health Care Systems Leadership is an interprofessional graduate program for nurses and other professionals interested in creating and leading innovation in health care. Students take a core group of courses in leadership and select from one of three concentrations:

1. **Health Promotion, Education, and Technology**
2. **Disaster Response and Emergency Preparedness**
3. **Clinical Nurse Leader (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.
POST-MASTER’S PROGRAM

Master’s prepared nurses may apply for postgraduate study in the following: acute care nurse practitioner, adult nurse practitioner, pediatric nurse practitioner, neonatal nurse practitioner, family nurse practitioner, gerontological nurse practitioner, and psychiatric/mental health nurse practitioner.

GRADUATE PROGRAM

Specific course and clinical requirements for each specialty can be found on the Web: www.urmc.rochester.edu/son/academicprograms/masters.cfm.

Curriculum revision at the graduate level is continuous and courses may be modified.

Core and Clinical Core Courses

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.

405. Principles of Clinical Research and Evidence-Based Practice
Credit—three hours

This is the first of two research courses in the master’s program to prepare advanced practice nurses with research competencies. This course focuses on (a) theoretical, methodological, and statistical concepts used in the development, implementation, and evaluation of clinical research; and (b) the foundations of evidence-based practice. Emphasis is placed on analysis and critique of research and theoretical reports as well as the process of searching for and determining the best evidence to guide advanced practice nursing.

406. Applying Theory and Research Evidence in Advanced Practice
Prerequisite: NUR 405.
Credit—three hours

This foundational course is the second of two courses in the master’s program focusing on developing competencies to evaluate, conduct, and utilize evidence in advanced practice. Evaluation and application of theory and research related to specific practice problems are emphasized in this course. The course prepares the student to synthesize the results of existing theory and research for practice, to collaborate with others in developing research projects, and to assist others in evaluation and application of evidence for practice.

407A. Physiological and Pathophysiological Basis of Advanced Nursing Practice
Prerequisite: undergraduate physiology.
Credit—one or 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 or permission of course coordinator.
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 Health Problems of Adults  
Pre- or co-requisites: NUR 407, NUR 410.  
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  
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: introduction to 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—one to four hours  
493. Comprehensive Examination  
Credit—none  
A comprehensive examination is required for all students selecting Plan B. Successful completion of a written comprehensive examination will demonstrate 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

Acute Care Nurse Practitioner

424. Acute Care Nurse Practitioner I  
Prerequisite: NUR 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. Both direct patient care and systems-oriented, advanced practice skills are included. Case examples and clinical experiences are provided in which students are expected to begin to implement the role of ACNPs with specialty populations across settings.
425. Acute Care Nurse Practitioner II
Prerequisites: NUR 424.
Credit—ten 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 I
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
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. Discussion 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
Prerequisite: NUR 412, 407A, 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 intervention strategies for infants requiring intensive care. The course also addresses content necessary to deliver comprehensive indirect care for this population of infants, such as discharge planning and provisions for follow-up care.

437. Leadership in Advanced Nursing Care of Children and Families: Advanced Concepts in Pediatric Primary Care
Prerequisite: NUR 412.
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 437.
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.

Adult Nurse Practitioner, Family Nurse Practitioner, and Gerontological Nurse Practitioner

415. Middle Age and Aging
Credit—three hours

A developmental course spanning the middle-adult and older-adult years. The course focuses on physical, psychological, and social development during the latter half of the life cycle. The purpose of the course is to provide an exposure to conceptual frameworks for the identification of health needs of middle-aged and older adults.

444. Primary Health Care I
Prerequisites: NUR 411, 419 (pre/corequisite), NUR 413 (pre- or corequisite for FNP students).
Credit—four or six hours (two didactic, four clinical for ANP and FNP students; two didactic, two clinical for GNP students)

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 consumer health care needs as they occur in the family environment.

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.

CLINICAL SPECIALTY 269
Emphasis is placed on differentiating symptomatology with attention to intervention and management techniques.

**449. Women's Health Care for Primary Care Generalists**  
*Prerequisite: completion of at least the first clinical course of the student's primary care clinical sequence.*  
*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**

**470. Psychopathology**  
*Credit—five hours (four didactic, one clinical)*

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 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.

**471. Individual Psychotherapy for the Psychiatric Mental Health Nurse Practitioner**  
*Prerequisite: NUR 470.*  
*Credit—five hours (two didactic, two clinical, one role)*

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. Nursing interventions are derived from various theoretical frameworks and applied to case examples. Psychotherapy research is examined, and implications for nursing practice and research are explored. Ethical and public policy issues related to the nursing practice of individual psychotherapy are addressed in terms of diverse client populations. Acquired knowledge is applied to the clinical practice of psychotherapy in a supervised psychotherapy experience with individual clients from diverse populations.

**472. Group Psychotherapy for the Psychiatric Mental Health Nurse Practitioner**  
*Credit—four hours (two didactic, two clinical)*

This course provides the theoretical basis for the understanding and implementation of group psychotherapy. Consumers include the group as client as well as the group as the context of care for the individual client. Students develop an advanced knowledge of current theories related to the practice of group psychotherapy and develop the beginning skills required of a psychiatric mental health nurse practitioner.

**473. Psychotherapy for the Psychiatric Mental Health Nurse Practitioner**  
*Credit—four hours (two didactic, two clinical)*

This course provides the theoretical basis for the understanding and implementation of family psychotherapy. Consumers include the family as client as well as the family as the context of care for the individual client. Students develop an advanced knowledge of current theories related to the practice of family psychotherapy and develop the beginning skills required of a psychiatric nurse practitioner.

**474. Special Interest Clinical for the Psychiatric Mental Health Nurse Practitioner**  
*Credit—two hours (one didactic, one clinical)*

Building on foundational knowledge from preceding master's coursework, this course provides a comprehensive clinical experience in psychiatric mental health nursing in
a setting of the student’s choice. The chosen clinical focus may be based upon a specific mental/emotional disorder (e.g., substance abuse, chronic mental illness, cognitive disorders), a particular modality (e.g., individual, group or family psychotherapy, psychopharmacological interventions), and/or a specific role or function (e.g., consultation/liaison, nurse-psychotherapist, case management). Class content is tailored to discuss cases and issues students encounter in their clinical settings. The course enhances the development of professional competence and skills in the APN role in collaboration with individual clients, families, and other health care providers. 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.

475. Pathophysiology of Mental Illness
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.

476. The Role of the Psychiatric Mental Health Nurse Practitioner
Credit—three hours (one didactic, two clinical)

The course enhances the development of professional competence and skills in the APN role in collaboration with individual clients, families, and other health care providers. 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.

477. Psychopharmacology
Credit—three hours (two didactic, one clinical)

This course provides an in-depth treatment 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 course foci.

Leadership in Health Care Systems

NLX 463. Foundations of Leadership and Organizational Behavior
Credit—four hours

This course provides students with an in-depth analysis of the principles of leadership and organizational behavior pertinent to health care systems. Students gain an understanding and application of leadership skills necessary to effectively lead high-performance, complex health care and community organizations in the twenty-first century. This course explores the role of the leader in designing systems for the effective management and evaluation of human resources, as well as organizational effectiveness with emphasis on organizational transformation.

NLX 465. Capstone Project and Essay
Credit—four hours

The purpose of the capstone course is to provide students with the opportunity to apply concepts, tools, and skills learned throughout the Leadership Program to a real-world executive-level project that will directly benefit an organization and a broader targeted community.

NLX 466. Epidemiology and Population Health Research
Credit—three hours

This course focuses on (a) theoretical, methodological, and statistical concepts used in the development and evaluation of population-based health programs and services; and (b) the foundations of epidemiology and population-based practice. Emphasis is placed on application of epidemiological strategies to planning and evaluation of population-based health initiatives and decision making in organizational leadership including searching for and determining the best evidence to guide program planning.
NLX 467. Global Public Health and Complex Human Emergencies
Credit—four hours

The course exposes students to global public health concepts, international health care organizations, and selected concepts in global health promotion and disease prevention. Topics include international health data sources, health care needs of international populations, and the theory of epidemiological transition. Health policy analysis and health care planning are considered in the context of international health issues and the provision of services through global networks.

NLX 468. Politics, Public Health Policy, and Ethics in Leadership
Credit—three hours

This course is a forum for the discussion of the politics, public policy, and ethical issues currently facing the American Health Care System. The evolution of U.S. health care services is presented as the background for analyzing the leadership and organizational dimensions of health policy and ethics in twenty-first-century health care.

NLX 469. Fundamentals of Disaster Management
Credit—five hours

This course provides an opportunity for health care professionals and others in the helping professions (e.g., teachers, administrators, social workers, EMTs) to acquire the knowledge and principles required to facilitate, manage, and coordinate prompt and effective management for a wide variety of disaster and/or major incident situations including natural disasters, acts of terrorism, and acts of war as experienced in a civilian population.

NLX471. Foundations and Application of Economics in Health Care Systems
Credit—four hours

This course integrates knowledge and principles of financial management with the delivery of health care and services. The unique factors that characterize the health care marketplace are discussed with an emphasis on economic impact of public policy on health care, health care reimbursement, third-party payer models, health care revenue cycle and related compliance issues, and responsibilities of leaders for resource management and cost containment.

NLX472. Health Promotion and Disease Prevention: Action for Health
Credit—five hours

This is a comprehensive online course that approaches community health program design as the integration of principles of population health, community collaboration and mobilization, behavior change, cultural competency, and program evaluation. Learning includes assessment of community health needs and design health improvement strategies to address important health issues and problems facing local and national population groups.

NLX473. Seminar in Health Promotion, Education, and Technology
Credit—four hours

This course covers a selection of current and emerging topics in health promotion, education, and technology. It is designed to build upon previous coursework to prepare learners with deeper awareness and critical understanding of community-based health services.

NLX474. Response to Chemical, Biological, and Radiological Emergencies
Credit—four hours

This course focuses on the knowledge and principles required to prepare for, manage, and coordinate prompt and effective response for a wide variety of chemical (hazardous materials), biological (bioterrorism), and radiological situations and emergencies. Topics include the unique threat posed by terrorism as well as emergencies resulting from nonterrorist-related events, such as industrial emergencies.

NLX475. 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.

493. Comp Exam
Credit—none
505. Epistemology and Concept Development  
Credit—three hours  
This course is an introduction to the epistemological debates about science in current nursing literature. These debates reflect different ways of knowing and arise out of different philosophical traditions, such as rationalism, empiricism, and pragmatism. An understanding of these debates informs the discussion about the nature of science and theory. The process of theory construction is examined from logical, deductive, and inductive approaches. The interrelationships between concepts, constructs, and variables are explicated for considering how study designs for generating and testing theory are developed.

506. Epistemology and Theory Construction  
Credit—three hours  
This course examines epistemological debates about science in current nursing 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. An understanding about these debates informs the discussion about the nature of science and methodological approaches to generating knowledge in nursing. Students apply knowledge gained about the process of theory construction to a specific area of interest in nursing science.

507. Research Programs  
Credit—three hours  
This course is designed to provide an overview of the interrelationship between philosophy of science, theory, research methods, and selected domains of research in nursing practice and health service delivery. The domains are selected to emphasize and study the development of programs of nursing research that are cumulative. Interrelationships among nursing theory and research and that of other disciplines are explored. Assignments are used to assist students in exploring these interrelationships in an area of personal interest.

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. Research Design  
Credit—three hours  
This course covers basic principles of research design primarily, but not exclusively, from the standpoint of evaluating planned interventions. The topics covered include the analyses of causal relationships; threats to validity; experimental, quasi-experimental, relational, and descriptive designs. Considerable attention is given to hypothesis formulation, sampling design, statistical power, control and comparison groups, stratification and factorial designs, measurement design, and the analysis of data and interpretation of results.

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  
Credits—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 Synthesis  
Credit—three hours  
The course provides 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 subjects for research, collaborative roles, and publications. Learning experiences include examination of published research and reviews of research, presentations of preliminary plans for a research project, preparation of a grant application using NIH guidelines, and peer review of applications.
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 Ph.D. 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 Ph.D. 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.

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**

In this course, qualitative research is described as a cover term for a variety of research traditions originating within anthropology and sociology, which are epistemologically and methodologically similar. The relevance of these approaches to advancement of knowledge and practice in the health sciences is explored. Examples of research that are representative of different qualitative approaches are analyzed in terms of structure, substance, and practical utility. This analysis also provides the context within which specific technical issues on how to conduct given types of research are most appropriately addressed.

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. Ph.D. Reading Course  
_Credit to be arranged (usually not to exceed three hours)_

595. Research for Doctoral Dissertation  
_Credit to be arranged_

For further information write to:  
Office of Student Affairs  
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School of Nursing  
Box SON  
601 Elmwood Avenue  
Rochester, New York 14642-8404
William E. Simon Graduate School of Business Administration

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PERSPECTIVE

The William E. Simon Graduate School of Business Administration has a faculty of 55, 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 750 students in the full- and part-time and executive M.B.A., M.S., and Ph.D. 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 M.B.A. degree, 67 credit hours of study (64 credit hours for part-time study) with a 3.0 grade point average must be completed. The M.B.A. program normally involves six quarters of full-time study, but exceptional students are able to complete it in a shorter period. All M.B.A. students have the option of taking a 21st and 22nd course free of charge within a year of completing the program.

The M.B.A. 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 M.B.A. Program, please visit us online at www.simon.rochester.edu/mba/default.aspx.
Master of Science in Business Administration

The master’s degree program offers eight concentrations: manufacturing management, service management, information systems management, technology transfer and commercialization, finance, marketing, medical management, and accountancy. 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 M.B.A. degree and may be earned by someone who already has an M.B.A. 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 39 credit hours of study. The technology transfer and commercialization concentration appeals to professionals committed to careers in technology transfer who need management expertise. The concentration is offered on a full-time and part-time basis and requires the completion of a minimum of 39 credit hours, corresponding to 12 quarter courses.

The finance program is designed for students who already have an M.B.A. and are interested in a concentration in the finance area and/or are considering a career change. This concentration requires the completion of a minimum of 36 credit hours of study (39 if required to take FIN 402).

The M.S. 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. While students are exposed to a variety of career possibilities while in the program, most 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 M.S. 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 M.S. 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 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).
The Master of Science in Accountancy program is designed for students seeking to pursue Certified Public Accounting (C.P.A.) 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 M.S. 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 M.S. programs, visit us online at [www.simon.rochester.edu/ms/default.aspx](http://www.simon.rochester.edu/ms/default.aspx).

**Executive M.B.A. Programs**

The mission of the Simon School’s Executive M.B.A. Program is to maximize the benefits of a general management M.B.A. for mid-career professionals. This program consists of two academic years of intensive M.B.A. classes. The integrated sequence of courses leads to a fully accredited Master of Business Administration from the University of Rochester. An executive M.B.A. 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 M.B.A. 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](http://www.simon.rochester.edu/emba).

**JOINT DEGREE PROGRAMS**

**M.B.A.-M.P.H.**

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 Simon School Catalog or contact the Office of the Associate Dean at the Simon School.

**Anesthesiology/M.B.A. Program**

Students completing a residency or clinical fellowship in anesthesiology are able to earn an M.B.A. degree through a joint program offered by the Department of Anesthesiology and the Simon School. The program design combines the residency or fellowship with business school coursework. This joint program prepares anesthesiologists for leading careers as physician executives in the health care management field.
M.B.A.-M.S. in Microbiology and Immunology

The Simon School, in conjunction with the Department of Microbiology and Immunology in the School of Medicine and Dentistry, offers a two-calendar-year program for the Master of Science and the Master of Business Administration degrees. Interested students may obtain more information from the Office of the Associate Dean at the Simon School.

M.D.-M.B.A.

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 Office of the Associate Dean at the Simon School.

For more information, visit us online at www.simon.rochester.edu/mba/joint_ft.asp

PH.D. PROGRAM

The Simon School offers a Ph.D. 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 in their first year take a set of “core” courses in one of the two underlying disciplines offered: economics or quantitative methods. This requirement reflects the Simon School’s view of what is important for researchers to know. 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 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 economics core 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 Ph.D. 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 Ph.D. degree.

**Admission and Financial Aid**

No particular undergraduate major is required for admission to the Ph.D. program, but some training in mathematics (at least a year of calculus) is essential. Most students electing the quantitative methods core have undergraduate degrees in mathematics or engineering. Students taking the economics core have more diverse backgrounds, but many have majored in either mathematics or economics. All students are required to spend the months of July and August before their first year honing mathematical 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 Ph.D. 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 international students is December 31. The application deadline for U.S. citizens is January 15.

For more information, see the Simon School Web site at [www.simon.rochester.edu/phd/default.aspx](http://www.simon.rochester.edu/phd/default.aspx).

**COURSES OF GRADUATE INSTRUCTION**

A complete listing of courses and course descriptions can be found in the current issue of *Simon Management Programs* (M.B.A. or M.S.), the E.M.B.A. Program catalog, or the Ph.D. 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 (Ph.D.).
Margaret Warner Graduate School of Education and Human Development

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Ellen Santora, Ph.D. (Pennsylvania State) . . . Assistant Professor of Education
Paul Stein, Ph.D. (Rochester) . . . Assistant Professor of Education (clinical)
Dena Phillips Swanson, Ph.D. (Emory) . . . Assistant Professor of Education
Andrew Wall, Ph.D. (Illinois) . . . Assistant Professor of Education

Evelyn Kirst, M.S. (Niagara) . . . Instructor (clinical)

Visiting Professors:
Cecilia Rios Aguilar, Ph.D. (Rochester) . . . Visiting Assistant Professor (part time)
Martha Mock, Ph.D. (Wisconsin) . . . Visiting Assistant Professor (part time)
Ruthanne Vitagliano, Ed.D. (SUNY, Buffalo) . . . Visiting Assistant Professor of Education

GENERAL INFORMATION

The Margaret Warner Graduate School of Education and Human Development offers programs leading to the Doctor of Philosophy (Ph.D.), Doctor of Education (Ed.D.), Master of Science (M.S.), and Master of Arts in Teaching (M.A.T.) degrees, as well as a few 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, a faculty body of the school. Admission decisions for master’s, Ed.D., and Ph.D. applicants are made at specific times during four application cycles, with deadlines in November, February, April, and July; Ph.D. applications are reviewed in the February cycle only.

Admission to all programs is based on the applicant’s record of academic achievement, letters of recommendation, personal interviews, and the fit of personal goals and interests with the Warner School’s 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) is required for foreign students whose native tongue is not English.

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, 2-130 Dewey Hall, or phone (585) 275-3950.

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 Web site at www.rochester.edu/warner.

DOCTORAL PROGRAMS

The Warner School offers two types of doctoral programs: Doctor of Philosophy (Ph.D.) and Doctor of Education (Ed.D.). The Ph.D. program is designed specifically to prepare students for careers devoted to research and scholarship, particularly in a university environment. The Ed.D. is designed to equip outstanding education professionals to undertake educational leadership responsibilities in both traditional and nontraditional settings.
Both 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 Ph.D. students and 36 credits for Ed.D. 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. Transfer credit decisions are made at the time of approving each student’s program of study.

In addition to coursework, doctoral students also need to successfully complete a set of experiences. First, 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 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. Finally, all doctoral programs culminate in the completion of a doctoral dissertation.

Advancement to candidacy for the Ph.D. or Ed.D. 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, must 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.

Ph.D. in Education

The Warner School offers several areas of study within the Ph.D. in Education. Students may concentrate in one of the following: (a) Policy and Theory; (b) Higher Education; (c) Teaching, Curriculum, and Change; (d) Human Development in Educational Contexts; (e) Counseling and Counselor Education, and (f) Mental Health Counseling and Supervision. Ph.D. 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 Ph.D. students.

**Ed.D. in Education**

The Ed.D. degree is available in the following areas: School Administration, Higher Education Administration, Teaching and Curriculum, Counseling, Mental Health Counseling and Supervision, 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 project.

Students specializing in school administration can obtain building-level or district-level certification during their course of study. Students specializing in counseling can obtain provisional and/or permanent certification in school counseling or become eligible for New York State licensure in mental health counseling.

The Warner School offers an accelerated option for Ed.D. students who are experienced practitioners in their field of specialization and want to pursue the degree part time while continuing to hold their employment. This option makes it possible for qualified students to complete the degree in three years on a part-time basis for most Ed.D. programs. Additional admission criteria and program requirements must be met by students choosing the accelerated option.

**Certificate of Advanced Study**

Under certain circumstances the Margaret Warner Graduate School of Education and Human Development 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 hours of graduate study.

**MASTER’S PROGRAMS**

The Margaret Warner Graduate School of Education and Human Development 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 occupational 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 NYS or become eligible for licensure. All these programs combine strong emphasis on professional excellence with the University’s commitment to sound scholarship.

All master's degrees require completion of at least 30 semester hours of coursework although many M.S. degree programs require additional credit hours (as indicated for each program listed in this section).
Of the minimum 30 semester hours, no more than 10 may be accepted as transfer credit. 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. 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 be taken within five years of the date of matriculation, (2) must receive 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 may be submitted in writing to the associate dean of graduate studies.

Students may pursue the M.S. 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 vary from program to program regarding the requirement of a master’s essay, thesis, or portfolio and conditions for fulfillment of field placement responsibilities. 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 Web site at www.rochester.edu/warner.

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 certifications in the same area.

**M.S. in Education**, leading to NYS teaching certification in one of the following areas:

- Early Childhood (birth–grade 2) **45 credits**
- Childhood (grades 1–6) **45 credits**
- Middle Childhood* (grades 5–9) **39 credits**

* These programs lead to NYS teaching certification in one or more of the following subjects: English, foreign languages (French, Spanish, German), Latin, mathematics, science (biology, chemistry, physics, earth science), social studies.
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

M.A.T. in (Subject Area),* leading to NYS teaching certification in Adolescence (grades 7–12) 51 credits

Students 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. Students interested in specializing in urban education could apply for 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.

M.S. in Education (same area of specialization) 30 credits
M.S. in Education (leading to NYS certification at a new grade level or in a different specialization) 32 credits
M.A.T. in (Subject Area) 30 credits
M.S. in Inclusive Education (also satisfying requirements for NYS certification in Teaching Students with Disabilities) 30–35 credits
M.S. in Reading and Literacies (also satisfying 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 (satisfying requirements for initial NYS certification in School Counseling) 48 credits
Community Mental Health Counseling (satisfying requirements to apply for NYS licensure) 60 credits
Gerontological Mental Health Counseling (satisfying requirements to apply for NYS licensure) 60 credits
School and Community Counseling (satisfying requirements for initial NYS certification and all academic requirements for permanent certification in School Counseling) 60 credits
Student Affairs Counseling (preparing for counseling in higher education settings) 51 credits
Programs Preparing Entry-Level School Administrators

Experienced teachers interested in assuming administrative positions in New York State are required to obtain a School Building Leader (S.B.L.) certification for positions at the building level, or School District Leader (S.D.L.) 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.

**M.S. in Educational Administration** (leading to S.B.L. or S.D.L. certification or both) 36 credits

**M.S. in Educational Administration** (with specializations in Catholic and other private school leadership and leading to S.B.L. certifications) 36 credits

**Master's Program 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.

**M.S. in Human Development** (with optional specializations in Early Childhood, Family Studies, Developmental Differences, Gerontology, or Research) 30 credits

**M.S. in Teaching and Curriculum** 30 credits

**M.S. in Educational Administration** (with concentrations in K–12 School Administration, Higher Education, or Student Affairs) 36 credits

**NON-DEGREE PROGRAMS**

Students who already hold a master’s degree but are seeking additional NYS certifications can also pursue their goal by enrolling in one of the Warner School 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–grade 2)
- Childhood (grades 1–6)
- Middle Childhood* (grades 5–9)
- Adolescence* (grades 7–12)
- Teaching Students with Disabilities (at one of the four grade levels listed above)
- Teaching Literacy (birth–grade 6 or grades 5–12)
- Teaching English to Speakers of Other Languages (K–12)

* Specializing in mathematics, English, social studies, biology, chemistry, physics, earth science, French, German, Spanish, or Latin.
Non-degree programs leading to administrative certification in the following areas:

School Building Leader (24 credits)
School District Leader (24 credits—assuming that additional 36 graduate credits have been previously completed).
School Building Leader (with specialization in Catholic and other private schools (24 credits)

Non-degree programs leading to 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):

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.

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

3+2 Options in Counseling and Human Development

Under a 3+2 option, University of Rochester undergraduate students who qualify begin graduate study in their senior year and complete the program in one year of postgraduate study.

Students in the 3+2 Counseling and Human Development program may study with concentrations in psychological development (45 credit hours), school counseling (48 credit hours), or community counseling (51 credit hours).

Applications for the 3+2 option 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.

4+1 Program

Undergraduate students interested in a teaching career can gain a jump start on their master’s programs by taking some of the required courses while they are juniors and seniors. These courses can later be transferred into an M.S. in Education leading to one of the NYS teaching certifications, up to a maximum of 12 credits—provided that these courses were taken in addition to the minimum of 128 credit hours required for graduation.
Fifth Year in Teaching Scholarship/Urban Teaching and Leadership Program

The University of Rochester recognizes the critical need for teachers of underprivileged students and through the Margaret Warner Graduate School of Education and Human Development 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 awards for full tuition for graduate study to qualified undergraduate students who apply for admission during their senior year at the University of Rochester and are accepted into one of the Warner School’s M.S. or M.A.T. degree programs leading to teaching certification and into the Urban Teaching and Leadership Program. These scholarships cover full tuition as well as on-campus room and board for students who prove financial need (some restrictions apply). Students who are not eligible for free room and board can obtain a forgivable loan to cover the cost of on-campus room and board. Fifth Year in Teaching Scholars must continue to attend courses and seminars and commit to teach in an urban setting for two years following graduation.

All the courses below carry 3 credit hours of graduate coursework, unless otherwise indicated. 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 Web site at www.rochester.edu/warner.

School-wide Courses

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 417. Education of American Women: A Social and Cultural History
ED 428. Ethics and Education
ED 432. Professional Writing and Communications
ED 435. Critical Thinking and Professional Practice
ED 440, 441, 442, 443, 444, and 445. Urban Teaching and Leadership Seminars
Credit—one hour
EDU 446. Entrepreneurial Skills for Educators
ED 461. The Politics of Education
ED 468. Leadership in Urban Schools
ED 481. School, Family, and Community Relations
ED 483. Communication and Counseling Skills for Teachers, Administrators, and Other Helping Professionals
ED 487. Developing Values and Character in the School, Home, and Community
EDU 497. Teaching and Learning in Higher Education
ED 504. Quantitative Research Methods: General Linear Analysis I
ED 505. Advanced Quantitative Research Methods: General Linear Analysis II
ED 506. Doctoral Research Methods
ED 507. Qualitative Research Methods
ED 508. Reasoning, Argument, and Explanation
ED 512. Pedagogies: Classical and New
ED 513. Academic Writing for Educators
ED 516. Designing and Evaluating Professional Development
ED 517. Schooling and Social Justice
ED 519. Key Ideas in Education: An Interdisciplinary Doctoral Seminar
ED 520. Introduction to Program Evaluation
ED 521. Advanced Program Evaluation
ED 522. Historical Research Methods
ED 523. Mixed Research Methods
ED 524. Survey Design
  Credit—one hour
ED 525. Interview and Focus Group Techniques
  Credit—one hour
ED 527. Advanced Qualitative Research Methods

Teaching and Curriculum
ED 400. Topics in Teaching and Schooling
ED 403. Disability and Early Childhood
ED 404. Teaching, Curriculum, and Change
ED 405. Assessment in Instructional Contexts
ED 407. Development, Learning, and Teaching for Children Ages 3 to 5
ED 408. Development, Learning, and Teaching for Children Ages Birth to 3
ED 409. Language and Literacy in Education
ED 415. Adolescent Development and Youth Culture (Ages 10 to 20)
EDU 427. Theory and Practice in Teaching and Learning Literacy in Elementary School
EDU 428. Theory and Practice in Teaching and Learning Social Studies in Elementary School
EDU 429. Theory and Practice in Teaching and Learning Science in Elementary School
EDU 430. Theory and Practice in Teaching and Learning Mathematics in Elementary School
EDU 431. Theory and Practice in Teaching and Learning English
EDU 432. Theory and Practice in Teaching and Learning Social Studies
EDU 433. Integrating Social Studies and Literacy
EDU 434. Theory and Practice in Teaching and Learning Science
EDU 435. Theory and Practice in Teaching and Learning Foreign Languages and ESOL
EDU 436. Theory and Practice in Teaching and Learning Mathematics
EDU 440. Children’s Literature and Literacy Learning
EDU 442. Race, Class, Gender, and Disability in American Education
EDU 443. Implementing Innovation in English Education
EDU 444. Implementing Innovation in Mathematics Education
EDU 446. Collaborative Teaching Partnerships in Inclusive Classrooms
EDU 447. Disability and Schools
EDU 448. Implementing Innovation in Science Education
EDU 451. Teaching and Learning in Inclusive Classrooms

EDU 527. Advanced Doctoral Seminar in Teaching and Learning
EDU 528. Using Quantitative Data Analysis Software
  Credit—one hour
EDU 528. Advanced Doctoral Seminar in Curriculum and Pedagogy: Alternative Pedagogies
EDU 529. Using Qualitative Data Analysis Software
  Credit—one hour
EDU 531. Case Study Design and Analysis
  Credit—one hour
EDU 538. Comprehensive Exam Seminar
EDU 539. Dissertation Proposal Writing Seminar
EDU 446. Collaborative Teaching Partnerships in Inclusive Classrooms
EDU 447. Disability and Schools
EDU 448. Implementing Innovation in Science Education
EDU 451. Teaching and Learning in Inclusive Classrooms
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, 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 405. Policy and Practice in Developmental Differences
ED 418. The Family and Social Dynamics
ED 419. Sociology of the Life Course
ED 425. Minority Youth Development in Urban Contexts
ED 427. Elementary School Counseling
ED 429. Theories of Human Development
ED 452. Instructional Strategies for Inclusive Classrooms
ED 453. Principles, Methods, and Applications in Applied Behavior Analysis
ED 485. College Students and Student Development Theory (EL)
EDU 486. Integrating Science and Technology
EDU 487. Integrating Science and Literacy
ED 489. Implementing Curriculum Reform in Mathematics
EDU 498. Literacy Learning as Social Practice
EDU 499. Integrating Social Studies and Technology
EDU 525. Theory and Research on Teaching and Learning
EDU 526. Theories and Research in Curriculum and Change
EDU 528. Advanced Doctoral Seminar in Curriculum and Pedagogy: Alternative Pedagogies
EDU 529. Advanced Doctoral Seminar in Teacher Education and Reform
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 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
EDU 470. Multicultural Perspectives in Counseling
EDU 471. Counselor as Systems Consultant
EDU 472. Introduction to Community Counseling
EDU 473. Social Organization of Work and Career
EDU 474. Addictions Counseling and Prevention
EDU 479. Promoting Mental Health in Midlife and Beyond
EDU 494. Human Development in Old Age

Educational Leadership
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
EDU 413. Contemporary Issues in Education Policy
EDU 416. Conflict Management in Schools and Universities
EDU 418. Leadership in Education
EDU 419. History of Educational Leadership through Biography
EDU 420. Learning and Assessment in Higher Education
EDU 420. Problems in Educational Leadership

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
Credit—four hours
EDU 557. Selected Theories of Human Development
EDU 560. Research in Cognitive Development
EDU 563. Advocacy, Consulting, and Systems Change as Counseling Practice
EDU 564. Contemporary Trends in Mental Health Appraisal, Intervention, and Research
EDU 565. Research in Life Course Studies
EDU 566. Counseling Theory, Research, and Practice

EDU 421. Human Resource Management
EDU 422. Educational Leadership: Implications for the Twenty-First Century
EDU 423. Educational Management and Human Relations
ED 424. Professions in American Culture
EDU 424. The Principal and Christian Concepts of Virtue
ED 430. College Retention: Theory, Research, and Practice
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
EDU 468. Data-Driven School Improvement
ED 469. Leadership and Organizational Dynamics
ED 470. Instructional Program Design
ED 472. Transforming Campus Communities through Experiential Learning
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
EDU 478. Professional Education: Past and Present
EDU 479. Human Capital Management in Higher Education
EDU 484. Curriculum in Higher Education
ED 485. College Students and Student Development Theory
ED 488. Women, Educational Leadership, and the Professions: A Historical Perspective
EDU 490. Higher Education Law
EDU 491. History of Student Affairs
EDU 492. Governance, Policy, and Administration of Higher Education
EDU 493. History of Higher Education
EDU 496. Fiscal Policy Issues in Higher Education
EDU 500. Great Books in Education
EDU 502. Leading the School District: The Superintendency in the Twenty-First Century
EDU 515. Decision Making for Educational Leaders I: Analyzing Problems in Schools and Universities

**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 Enrollment (Master's)
ED 899. Master's Thesis
ED 995. Continuation of Enrollment (Doctoral)
ED 999. Master's Thesis
ED 985. Leave of Absence

Leaves of absence are available, with the written approval of the associate dean, for (a) medical reasons pertaining to the student’s health, (b) professional reasons pertaining to the student’s occupation, and (c) personal reasons pertaining to the student’s personal life.
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*.

**Arts and Sciences**

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<th>Program Code</th>
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<th>Program Name</th>
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## Joint Degree Programs

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University Administration

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Provost . . . Charles E. Phelps

Senior Vice President for Administration and Finance and Chief Financial Officer . . . Ronald J. Paprocki
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