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Ayala Emmett, Ph.D. (Rochester) . . . Associate Professor of Anthropology
Mark Fey, Ph.D. (California Institute of Technology) . . . Associate Professor of Political Science
Signithia Fordham, Ph.D. (American University) . . . Associate Professor of Anthropology and Susan B. Anthony Professor of Gender and Women’s Studies
Jean France, M.A. (Oberlin) . . . Adjunct Associate Professor of Art History
Gerald Gamm, Ph.D. (Harvard) . . . Associate Professor of Political Science and of History
Alfred Geier, Ph.D. (Johns Hopkins) . . . Associate Professor of Classics
Thomas Gibson, Ph.D. (London) . . . Associate Professor of Anthropology
John Givens, Ph.D. (Washington) . . . Associate Professor of Russian
Hal Gladfelder, Ph.D. (California, Los Angeles) . . . Associate Professor of English
Lynn D. Gordon, Ph.D. (Chicago) . . . Associate Professor of Education and of History
George Grella, Ph.D. (Kansas) . . . Associate Professor of English and of Film Studies
Randall Halle, Ph.D. (Wisconsin-Madison) . . . Associate Professor of German and of Visual and Cultural Studies
Frederick Harris, Ph.D. (Northwestern) . . . Associate Professor of Political Science
Ewa Hauser, Ph.D. (Johns Hopkins) . . . Adjunct Associate Professor of Political Science
Sarah Higley, Ph.D. (California, Berkeley) . . . Associate Professor of English
Larry E. Hudson, Ph.D. (Keele) . . . Associate Professor of History
Naomi Jochnowitz, Ph.D. (Harvard) . . . Associate Professor of Mathematics
James Johnson, Ph.D. (Chicago) . . . Associate Professor of Political Science
Barbara Jordan, M.A. (Boston) . . . Associate Professor of English
Beth Jorgensen, Ph.D. (Wisconsin) . . . Associate Professor of Spanish
Rosemary Kegl, Ph.D. (Cornell) . . . Associate Professor of English
Cilas Kemedjio, Ph.D. (Ohio State) . . . Associate Professor of French
Shakeeb Khan, Ph.D. (Princeton) . . . Associate Professor of Economics
David Knill, Ph.D. (Brown) . . . Associate Professor of Brain and Cognitive Sciences and in the Center for Visual Science
Steven E. Landsburg, Ph.D. (Chicago) . . . Adjunct Associate Professor of Economics
Elias Mandala, Ph.D. (Minnesota) . . . Associate Professor of History
Steven Manly, Ph.D. (Columbia) . . . Associate Professor of Physics and Mercer Brugler Distinguished Teaching Professor
Joyce McDonough, Ph.D. (Massachusetts) . . . Associate Professor of Linguistics
Kevin McFarland, Ph.D. (Chicago) . . . Associate Professor of Physics
Ernestine McHugh, Ph.D. (California, San Diego) . . . Associate Professor of Anthropology and Religion in the Eastman School of Music and Associate Professor of Anthropology
Randal C. Nelson, Ph.D. (Maryland) . . . Associate Professor of Computer Science
Thomas O’Connor, Ph.D. (Virginia) . . . Associate Professor of Psychiatry and of Psychology
William E. O’Neill, Ph.D. (SUNY, Stony Brook) . . . Associate Professor of Neurobiology and Anatomy and of Brain and Cognitive Sciences
Jean Pederson, Ph.D. (Chicago) . . . Associate Professor of History in the Eastman School of Music and of History
Alexandre Pouget, Ph.D. (California, San Diego) . . . Associate Professor of Brain and Cognitive Sciences, in the Center for Visual Science, and of Biomedical Engineering
Jeffrey Runner, Ph.D. (Massachusetts, Amherst) . . . Associate Professor of Linguistics
Grace Seiberling, Ph.D. (Yale) . . . Associate Professor of Art History
Joel I. Seiferas, Ph.D. (M.I.T.) . . . Associate Professor of Computer Science
Curtis Signorino, Ph.D. (Harvard) . . . Associate Professor of Political Science
John Spoonhower, Ph.D. (Cornell) . . . Adjunct Associate Professor of Physics and Astronomy
Donatella Stocchi-Perecchio, Ph.D. (Cornell) . . . Associate Professor of Italian
Randall Stone, Ph.D. (Harvard) . . . Associate Professor of Political Science
Ted Supalla, Ph.D. (California, San Diego) . . . Associate Professor of Brain and Cognitive Sciences and of Linguistics
Allen Topolski, M.F.A. (Pennsylvania State) . . . Associate Professor of Art
Michael Veliky, Ph.D. (California, Berkeley) . . . Associate Professor of Brain and Cognitive Sciences and in the Center for Visual Science
Peter Wyman, Ph.D. (Rochester) . . . Associate Professor of Psychiatry and of Psychology
Rachel Ablow, Ph.D. (Johns Hopkins) . . . Assistant Professor of English
Árpád Ábrahám, Ph.D. (Universitat Pompeu Fabra) . . . Assistant Professor of Economics
Irasema Alonso, Ph.D. (Minnesota) . . . Assistant Professor of Economics
Diministr Anastasopoulos, Ph.D. (SUNY, Albany) . . . Assistant Professor of English
Matthew BaileyShea, Ph.D. (Yale) . . . Assistant Professor of Music and of Musicology in the Eastman School of Music
Loisa Bennetto, Ph.D. (Denver) . . . Assistant Professor of Psychology
Xin Bi, Ph.D. (Johns Hopkins) . . . Assistant Professor of Biology
Beth Buggenhagen, Ph.D. (Chicago) . . . Assistant Professor of Anthropology
Marine Carrasco, Ph.D. (Toulouse Institute) . . . Assistant Professor of Economics
Kevin Clarke, Ph.D. (Michigan) . . . Assistant Professor of Political Science
Emile Devereaux, M.F.A. (California, San Diego) . . . Assistant Professor of Art
Chen Ding, Ph.D. (Rice) . . . Assistant Professor of Computer Science
Edward Freedman, Ph.D. (Pennsylvania) . . . Assistant Professor of Neurobiology and Anatomy and in the Center for Visual Science
Alison Frontier, Ph.D. (Columbia) . . . Assistant Professor of Chemistry
James Fry, Ph.D. (Michigan) . . . Assistant Professor of Biology
Carmala N. Garzione, Ph.D. (Arizona) . . . Assistant Professor of Geology
Daniel Gildea, Ph.D. (California, Berkeley) . . . Assistant Professor of Computer Science
Henk Goemans, Ph.D. (Chicago) . . . Assistant Professor of Political Science
Vera Gorbunova, Ph.D. (Weismann Institute of Science) . . . Assistant Professor of Biology
Christine Gunlogson, Ph.D. (California, Santa Cruz) . . . Assistant Professor of Linguistics
Muhammet F. Guvenen, Ph.D. (Carnegie-Mellon) . . . Assistant Professor of Economics
Rachel Haidu, Ph.D. (Columbia) . . . Assistant Professor of Art History
Kimberley Healey, Ph.D. (Pennsylvania) . . . Assistant Professor of French
Wendi Heinzelman, Ph.D. (M.I.T.) . . . Assistant Professor of Electrical and Computer Engineering and of Computer Science
Gretchen Helmke, Ph.D. (Chicago) . . . Assistant Professor of Political Science
Patrick Holland, Ph.D. (California, Berkeley) . . . Assistant Professor of Chemistry
John Howell, Ph.D. (Pennsylvania State) . . . Assistant Professor of Physics and Astronomy
Krystal Huxlin, Ph.D. (Sydney) . . . Research Assistant Professor of Ophthalmology and in the Center for Visual Science
Michael Jarvis, Ph.D. (William and Mary) . . . Assistant Professor of History
Rulanq Jiang, Ph.D. (Wesleyan) . . . Assistant Professor of Biomedical Genetics in the Center for Oral Biology and of Biology
Anastassios Kalandrakis, Ph.D. (California, Los Angeles) . . . Assistant Professor of Political Science
Keith Karn, Ph.D. (Rochester) . . . Adjunct Assistant Professor in the Center for Visual Science
Mark Kayser, Ph.D. (California, Los Angeles) . . . Assistant Professor of Political Science
Melinda Knight, Ph.D. (New York University) . . . Professorial Lecturer in the William E. Simon Graduate School of Business Administration and Assistant Professor of English
Todd D. Krauss, Ph.D. (Cornell) . . . Assistant Professor of Chemistry
David Lambert, Ph.D. (Arizona) . . . Assistant Professor of Biology
Daeyeol Lee, Ph.D. (Illinois, Urbana-Champaign) . . . Assistant Professor of Brain and Cognitive Sciences and in the Center for Visual Science
Nabi Magomedov, Ph.D. (Ohio State) . . . Assistant Professor of Chemistry
David J. McDowell, Ph.D. (California, Riverside) . . . Assistant Professor of Psychology
Bonnie Meguid, Ph.D. (Harvard) . . . Assistant Professor of Political Science
Anne Merideth, Ph.D. (Princeton) . . . Assistant Professor of Religion
Rita Miller, Ph.D. (Northwestern) . . . Assistant Professor of Biology
Andrés Nader, Ph.D. (Cornell) . . . Assistant Professor of German
Samuel Nelson, J.D. (Syracuse) . . . Assistant Professor of English and Director of Forensics
Man Kit Ng, Ph.D. (Chicago) . . . Assistant Professor of Chemistry
Greta Niu, Ph.D. (Duke) . . . Assistant Professor of English
Mikhail Ovchinnikov, Ph.D. (Utah) . . . Assistant Professor of Chemistry
Jonathan Pakianathan, Ph.D. (Princeton) . . . Assistant Professor of Mathematics
Jeff Pelz, Ph.D. (Rochester) . . . Adjunct Assistant Professor in the Center for Visual Science and of Computer Science
Ryan Prendergast, Ph.D. (Emory) . . . Assistant Professor of Spanish
David Primo, Ph.D. (Stanford) . . . Assistant Professor of Political Science
Alice Quillen, Ph.D. (California Institute of Technology) . . . Assistant Professor of Physics and Astronomy
Anne Reinhardt, Ph.D. (Princeton) . . . Assistant Professor of History
James Ripley, D.M.A. (Eastman School of Music) . . . Assistant Professor of Conducting and Ensembles and of Music
Ratíl Rodríguez-Hernández, Ph.D. (Cornell) . . . Assistant Professor of Spanish
Ronald Rogge, Ph.D. (California, Los Angeles) . . . Assistant Professor of Psychology
Lizabet Romanski, Ph.D. (Cornell) . . . Assistant Professor of Neurobiology and Anatomy and in the Center for Visual Science
Joan Saab, Ph.D. (N.Y.U.) . . . Assistant Professor of Art History and of Visual and Cultural Studies
Uta Schönberg, Ph.D. (University of London) . . . Assistant Professor of Economics
L. Brett Cornish Scott, D.M.A. (Cincinnati) . . . Assistant Professor of Music
Scott Seidman, Ph.D. (Case Western) . . . Assistant Professor of Biomedical Engineering, of Neurobiology and Anatomy, and in the Center for Visual Science
Kai Shen, Ph.D. (California, Santa Barbara) . . . Assistant Professor of Computer Science
Marni Shindelman, M.F.A. (Florida, Gainesville) . . . Assistant Professor of Art
Elaine Sia, Ph.D. (Columbia) . . . Assistant Professor of Biology
Valeria Sinclair-Chapman, Ph.D. (Ohio State) . . . Assistant Professor of Political Science
Harry Stern, Ph.D. (Columbia) . . . Assistant Professor of Chemistry
Jeffrey Tucker, Ph.D. (Princeton) . . . Assistant Professor of English
Thomas Tucker, Ph.D. (California, Berkeley) . . . Assistant Professor of Mathematics
Gabriel Uzquiano, Ph.D. (M.I.T.) . . . Assistant Professor of Philosophy
Inger Williams, Ph.D. (Pennsylvania State) . . . Adjunct Assistant Professor in the Center for Visual Science
Lisa Willis, Ph.D. (Rochester) . . . Senior Instructor in Psychiatry and Assistant Professor of Psychology
Victoria W. Wolcott, Ph.D. (Michigan) . . . Assistant Professor of History
Wenhao Wu, Ph.D. (Chicago) . . . Assistant Professor of Physics
Mo Xiao, Ph.D. (California, Los Angeles) . . . Assistant Professor of Economics
Paulo Barelli, M.Phil. (Columbia) . . . Instructor in Economics
Genevieve Guenther, B.A. (Columbia) . . . Instructor in English
Gábor Virág, M.A. (Central European University) . . . Instructor in Economics
Kathryn Argetsinger, Ph.D. (Princeton) . . . Senior Lecturer in Classics
Priscilla Auchenloss, 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 Maslennikova, 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. The
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 18 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 Angerer, Eickbush (Chair), Goldfarb, Gorovsky, Hinkle, Jaenike, Olmsted, Orr, Werren
Associate Professor Benyajati
Assistant Professors Bi, Fry, Gorbunova, Lambert, Miller, Sia
Joint Appointments: Professor Platt; Assistant Professor Jiang
Professors Emeriti Bannister, Hall, Hattman, 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-development biology, evolutionary biology, and genetics.

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.

406. Eukaryotic Genomes
Prerequisite: introductory course in genetics.

Broad overview of the origins, variations in size and organization, the proliferation of seemingly useless DNA, and the complex expression mechanisms that characterize eukaryotic genomes. While this course is a true “molecular” course, it is based on Dobzhansky’s premise that “nothing in biology makes sense except in the light of evolution.” It attempts to wed interests in molecular genetics with molecular evolution.

419. Advanced Cell Biology: Nuclear Structure and Function
Prerequisites: introductory course in genetics, biochemistry, and molecular biology are strongly recommended.

The structure and function of formed elements in the nucleus are discussed. Emphasis is on understanding how knowledge in this field is acquired, rather than on a comprehensive treatment of all nuclear structures and functions. This understanding is obtained by analyzing original data, both in lectures and by independent reading of significant papers in the field.

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.

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.

Addresses key cellular and developmental processes using state-of-the-art techniques (including microscopy, electrophoresis, immunocytochemistry, blotting of proteins and nucleic acids, in situ hybridization, nucleic acid isolation, hybridization and autoradiography). The course is designed to provide training in specific methods, data acquisition and analysis, and sampling problems.

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.

437. Advanced Developmental Biology
Prerequisite: introductory course in developmental biology or permission of the instructor.

This course pursues independent reading and in-depth discussions of classic and current literature aimed at understanding the cellular and molecular mechanisms underlying animal development. Topics include axis formation in invertebrates and vertebrates, formation of developmental compartments and boundaries, limb development, stem cells, and cloning.
IND 443. Eukaryotic Gene Regulation
Prerequisites: introductory courses in genetics, biochemistry, and molecular biology are strongly recommended.

This course examines the organization of eukaryotic genomes, DNA packaging into inactive and active chromatin, higher order structure, mechanisms of transcription initiation and mechanisms of regulated gene expression. Lectures and readings draw heavily on experiments from the primary literature both classic and most recent.

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.

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

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

Cell Biology/Molecular Biology

Several other courses in the field of cell and molecular biology are offered in the School of Medicine and Dentistry. See the section headed Interdepartmental Courses on page 230.

Brain and Cognitive Sciences

Professors Aslin, Chapman, Hayhoe, Ison, Jacobs, Kellogg, Makous, Newport (Chair), E. Nordeen, K. Nordeen, Tanenhaus, Williams
Associate Professors Bavelier, Knill, Pouget, Supalla, Weliky
Assistant Professor Lee
Joint Appointments: Professors Allen, Ballard, Carlson, Duffy, Klorman, Merigan, Paige, Pasternak, Schieber; Associate Professors Como, O’Neill

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 re-
markable 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.

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.

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.

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

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

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

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

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
The Department of Chemistry concentrates on programs leading to the Ph.D. degree. Fields of research include all major areas of biophysical, inorganic, organic, nuclear, and physical chemistry, as well as chemical physics, laser spectroscopy, and theoretical chemistry.

The department occupies modern facilities providing research and teaching laboratories, mechanical and electrical shops, and a chemistry-biology-mathematics library. The department currently maintains a full complement of 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. The department's nuclear chemistry group pursues an active program of research at several large accelerator laboratories in the United States and abroad. A unique collaborative effort on the part of the Department of Chemistry, Xerox Corporation, and Eastman Kodak Company, which is known as CPCT (Center for Photoinduced Charge Transfer) provides additional research and instructional opportunities. Computing facilities are available within the department.

Applicants for admission to graduate work in chemistry should have at least one year each, including appropriate laboratory work, of general chemistry, organic chemistry, and physical chemistry, lecture and laboratory work in inorganic and analytical chemistry, mathematics through differential and integral calculus and including an introduction to differential equations, and one year of physics. The Graduate Studies Office in chemistry 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). Additional courses may be required by the graduate committee in consultation with the students' research directors, but the course load after the first year normally does not exceed one course 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 must 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 entirely 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. Courses numbered 200–399 carry three graduate credit hours unless otherwise noted.
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. Mechanistic Inorganic Chemistry
   Reactions of metal complexes with special emphasis on organometallic compounds and catalysis.

412. Advanced Inorganic Chemistry II
   Prerequisite: CHM 411.
   Symmetry and group theory; spectroscopy of inorganic complexes; NMR spectroscopy; X-ray crystallography.

413. Organometallics
   An introduction to organometallic chemistry, including electron-counting formalisms, ligand substitution, insertion and elimination, oxidative addition and reductive elimination, and related reactions.

414. Coordination Compounds and Bio-Coordination Chemistry
   Prerequisite: CHM 411, or 211 with permission of instructor.
   Principles of inorganic chemistry relevant to living systems: structures and mechanisms of bioinorganic systems.

421. Introduction to Polymer Chemistry
   Prerequisites: Organic Chemistry and Physical Chemistry or equivalents.
   An 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. (Fall)

423. Physical Chemistry and Characterization of Polymers
   Prerequisite: CHM 421 or equivalent or permission of instructor.
   Various aspects of the physical chemistry of macromolecules will be described in the context of the direct experimental observation of these properties. Particular emphasis will be given to the interpretation of characterization data from both solution and bulk measurements on polymers, as well as comparison to theoretical predictions. (Fall, odd years)

424. Synthetic Polymer Chemistry
   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. (Spring, even years)

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. Organic Structure Determination
   The modern methods and tools employed for structure determination of complex organic molecules. Topics covered include NMR (1D and 2D Fourier Transform), IR, UV, and mass spectrometry.

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. Strategy and Tactics in Organic Synthesis
   A continuation of the survey reactions with particular emphasis on those having practical utility in synthesis, and a discussion of synthetic design principles with illustrations from published syntheses of complex organic molecules.
451. Quantum Chemistry I
Introduction to quantum chemistry covering quantum mechanical principles, simple systems, atoms, molecules, and spectroscopy. Required of all graduate students in physical chemistry. (Fall)

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

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

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
This course provides the student with an overview of modern concepts in computational chemistry. Lectures are complemented with practical computer exercises. Topics discussed include force field methods, electronic structure theory, semiempirical methods, electron correlation, density functional theory, molecular properties, molecular dynamics simulation, Monte Carlo simulation, path integrals, transition state theory, thermodynamic integration and perturbation, solvation, phase equilibria, liquids and solids, linear response theory.

511. Physical 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
The 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. Colloquium
No credit
Required each year of all graduate students in chemistry.
Clinical and Social Sciences in Psychology

Professors Cicchetti, Deci, Elliot, Ilardi, Klorman, McAdam, Reis, Ryan, Smetana, Zuckerman (Chair)
Associate Professors Aubé, Davies
Assistant Professors Bennetto, McDowell, Rogge
Joint Appointments: Cross, O'Connor, Perlis, Williams, Willis, Wyman
Professors Emeriti 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 the interdisciplinary area should apply either to the clinical 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 the students' entry into the department, a faculty member is appointed to advise the students 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. Passage of 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 psychol-
ogy 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 and 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, the development and maintenance of resilient outcomes among high-risk children, attachment and self-organization, and maltreatment. 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. The department's main server is a Sun SPARC server and hosts the department's Web site and e-mail services. Internet access via ethernet is accessible to all faculty and graduate student offices. The department also 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

211. Introduction to Statistical Methods in Psychology
219W. Research Methods in Psychology
266. Research Laboratory in Social Psychology
373. Exploring Research in Social Psychology I
374. Exploring Research in Social Psychology II
377. Exploring Research in Family Psychology I
378. Exploring Research in Family Psychology II

Advanced Lecture Courses

209. Psychology of Human Sexuality
241. Sleep Research and Sleep Medicine
262. Human Motivation and Emotion
263. Relationship Process and Emotions
264. Industrial and Organizational Psychology
267. Psychology of Gender

Seminar Courses

301. Teaching Psychology
361. Social Psychology: Self-Concept
362W. Seminar in the Psychology of Gender
363. Attitudes: Structure, Function & Change
364. Achievement and Motivation
366. Social Psychology and Control
367W. Gender & Mental Health
368W. Seminar in Humanistic Psychology
371. Seminar in Social & Personality Development
376. Seminar in Self-Determination
380. Theoretical Perspectives on Psychotherapy
381. Psychology of Developmental Disabilities
382. Abnormal Psychology
383. Behavioral Medicine
384. Practicum in Developmental Disabilities I
385. Practicum in Developmental Disabilities II
386. Practicum in Developmental Psychopathology I
387. Practicum in Developmental Psychopathology II
388. Research Practicum in Developmental Psychopathology I
389. Research Practicum in Developmental Psychopathology II
396. Seminar in Special Topics

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

501. Ethical Issues in Clinical Psychology

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

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

508. Psychology of Attitudes

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.

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

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.

558. The Social Self
Prerequisite: permission of instructor.
Focuses on that part of the self which is the product of social interaction, and the processes through which it is formed. Considers classic theoretical approaches, contemporary theory, and current empirical findings. Focuses on two or more central unsolved problems. Graduate students only. Seminar format. Term paper. Limited to 10.

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).

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

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

568. Psychology of Health
The course examines the effect of personality and situational variables on health.

569. Developmental Theory and Research
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.

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
Theoretical and research approaches to the psychopathology of childhood and adult life.
576. Psychopathology II
Continuation of CSP 575.

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

584. Psychotherapy Practicum I

585. Psychotherapy Practicum II

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

598. Seminar in Teaching
Readings, preparation of reports, and discussions of topics in the important relevant literature; evaluation, 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, Knill, McDonough, Nelson, Pouget, Runner, Supalla, Weliky
Assistant Professor Lee

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.

Computer Science

Professors Allen, Ballard, Brown, Hemaspaandra, LeBlanc, Ogihara (Chair), Schubert, Scott
Associate Professors Dwarkadas, Nelson, Seiferas
Assistant Professors Ding, Gildea, Shen
Adjunct Assistant Professor Pelz
Joint Appointments: Professors Hayhoe, Jacobs, Kyburg; Assistant Professor Heinzelman
Lecturer Pawlicki
Scientists Bukys, Ferguson

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. can-
didacy 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 edu-
cation 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.

453. High Performance Microprocessors
Current high-performance microprocessor architectures and leading research directions. Circuit and microarchitecture of advanced superscalar processors: in-depth view of out-of-order execution logic, advanced branch prediction, value prediction, etc. VLIW basics: IF-conversion, modulo scheduling, and data/control speculation. Parallel architecture and multiprocessor design: directory-based cache coherence protocol, various shared-memory architectures, and thread-level speculation. Low-power design: logic and microarchitecture-level low-power design, dynamic adaptation.

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, multiprocessor 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.
Earth and Environmental Sciences

Professors Basu, Fehn, Mitra, Poreda, Tarduno (Chair)
Assistant 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, environmental geochemistry and biogeochemistry, micropaleontology and paleoceanography, 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 programs. 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 impacts on the history of life.

The center’s four mass spectrometers support research in geochemistry. These instruments include 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 preparation 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 spinner magnetometer. Data are analyzed using Sun Microsystems UltraSparc workstations.

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

Other analytical equipment includes an automated powder X-ray diffractometer, a UV-VIS spectrophotometer, 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.

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

207. 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. 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 Environmental 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.
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 diagenesis.

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.

EARTH AND ENVIRONMENTAL SCIENCES   105
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 cosmogetic 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)

273/473. Evolutionary Paleontology
This course offers an introduction to current research topics in paleontology. At the molecular level, we look at the relationship between lineages based on stratigraphic and molecular data, and at early life and primordial environments. At the organismic level, topics include morphometry, cladistics and the fossil record, and paleobiogeography. Finally, we consider evolutionary ecology topics such as the development of diversity and mass extinction events.

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)

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 each semester. Classwork involves 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 in thrust mechanics and geometry. (Spring)
489. Topics in Advanced Structural Geology  
Prerequisite: permission of instructor.  
An advanced structural geology course to cover topics of current research interest. Topics to vary from term to term.

490. Supervised College Teaching  
Credit—one hour

491. Master's Readings in Geology

492. Graduate Field Seminar  
Credit to be arranged

Economics

Professors Bils, Engerman, Epstein, Greenwood, Jones, Oi, Ploberger, Stockman (Chair), Thomson  
Associate Professors Dahl, Khan  
Assistant Professors Ábrahám, Alonso, Carrasco, Guvenen, Schöenberg, Xiao  
Adjunct Associate Professor Landsburg  
Joint Appointments: Professors Phelps, Plosser; Associate Professor Duggan  
Instructors Barelli, Virág  
Senior Lecturer Wolkoff  
Professor Emeritus McKenzie

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

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

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.

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.)

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.

Elements of probability theory and statistics, as employed in the econometrics sequence ECO 484–485.

Topics in economic theory, with papers by faculty and outside speakers. Students are expected to be informed discussants and to present a paper.
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 sub-game 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
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, depending on the candidate's preparation, 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. At 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 the literature and scholarship of 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

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.

435. Modern Drama

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 Brown (Chair), Hauser, Inikori, Kaeuper, Outram, Rubin, Weaver, Westbrook
Associate Professors Applegate, Borus, Hudson, Mandala
Assistant Professors Jarvis, Reinhardt, Wolcott
Joint Appointments: Professors Engerman, Segal, Walsh; Associate Professors Gamm, Gordon, Pedersen
Professors Emeriti Berman, McGrath, Meehan, 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.

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; knowledge of one language is required of all candidates for the Ph.D. in American history and for the M.A. in history.

Ph.D. candidates who receive fellowships awarded by the department normally serve as apprentice teachers during the second semester of their first year of residence and 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. Apprentice teachers will register for HIS 590 and 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 six hours, except HIS 491, 495, 591, and 595.
402. The Idea of Race in Europe, 1700–2000
The focus of this course is the evolving European ideas of race and the implications of race-thinking throughout the modern era. Topics to be explored are racism and slavery; Enlightenment ideas of race; race, empire, and genocide; and scientific views of race since World War II.

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

404. 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.

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. Introduction to Labor History
Comparative study of labor history in Europe and the United States from the Industrial Revolution to the present.

410. Dylan’s America: 60s Culture and Politics
Explores the intellectual and cultural life of the 1960s through Dylan’s particular and unique version of the United States. At issue is less his career and the meaning of his work than the context in which it arose.

411. Progressive America
Study of the cultural, intellectual, and political life of the United States, 1900 to 1920.

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.

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.

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.
428. Victorian England
   A graduate seminar on the history of nineteenth-century Britain.

430. Topics in Russian and Soviet History
   Seminar on selected topics in Russian and Soviet 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.

447. Tokugawa Japan, 1560–1850
   Political, social, economic, intellectual, and demographic history of early modern Japan. Emphasis on critical analysis.

448. Modern Japan, 1850–1945
   Evolution of Japan as a modern state, with special emphasis on those forces that contributed to Japan’s successful response to the West.

449. Postwar Japan, 1945–Present
   Examines the political, social, economic, and cultural history of postwar Japan.

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 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.

478. History of American Popular Culture
This course 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.

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).

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).

489. Gender in Late Imperial and Modern China
This course examines gender under a succession of regimes in Chinese history: the Confucian/imperial order, missionary reformism, elite modernization, and state socialism.

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.

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. Reading 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.

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

Linguistics

Professors *Allen, Carlson (Chair), *Tanenhaus
Associate Professors McDonough, Runner, *Supalla
Assistant Professor Gunlogson
Professors Emeriti Carlton, Moutsos, Sapon

* Primary appointment in another department
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 field. The department offers the following orientation:

1. Familiarity with contemporary linguistic studies in the generative tradition.
2. Exploration of the relationship between theoretical linguistics and other fields of cognitive science.
3. The pursuit of independent research.
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, 514 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.

Mathematics

Professors Cohen, Gage, Gonek, Greenleaf, Harper, Lavine, Lubkin, Mueller, Neisendorfer, Pizer, Ravenel (Chair), Segal
Associate Professor Jochnowitz
Assistant Professors Pakianathan, Tucker
Adjunct Professor Moore
Joint Appointment: Professor Clark
Visiting Assistant Professors Dean, Hahn, Heap, Jackson, Lee, Pribble
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.

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 theory, divisors. Class 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. 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. Algebraic Geometry II
Local algebra, applications to intersection theory.

541. 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.

542. 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.

543. 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.

544. Homotopy Theory
Prerequisite: MTH 543.
The basic theory through the Hurewicz and Whitehead theory. Detailed discussion of algebraic 2-types based on paper of Eilenberg-MacLane and MacLane-Whitehead. If time permits, the Eilenberg-Whitehead formulation of obstruction theory will be developed and application made.

545. Characteristic Classes
Prerequisite: knowledge of cohomology theory.
Vector bundles, characteristic classes, cobordism.
546. Cohomology

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

549. Topics in Algebraic Topology
Introduction to research in algebraic topology; course covers: cup products, fibrations, spectral sequences, and cohomology operations with particular attention to Eilenberg-MacLane spaces.

550. Topics in Topology
Topics are related to recent research in the field.

551. Riemann Surfaces
Definition of Riemann surfaces and the many ways from which they arise. Compact Riemann surfaces, elliptic and hyperelliptic cases; functions and differentials; divisors, special divisors, the Riemann-Roch, Abel, and Jacobi inversion theorems.

552. Integral Geometry
Topics from “classical” integral geometry with applications to geometric inequalities (measures for sets of lines, planes, hyperplanes, in $\mathbb{R}^2$, $\mathbb{R}^3$, and $\mathbb{R}^n$); measures for geodesics; kinematic measure, Crofton formulae, Blaschke formulae.

553. Differentiable Manifolds
Prerequisites: MTH 237 and 440.
Differentiable manifolds, mappings and embeddings, exterior differential forms, affine connections, curvature and torsion, Riemannian geometry, introduction to Lie groups and Lie algebras.

555. 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 $\mathbb{C}$ 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
Credit—none
One classroom hour per week of discussion and problem solving with a small group of University of Rochester students, under the guidance of a member of the faculty.

591. Reading Course at the 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.

Philosophy

Professors Braun, Conee, Feldman, Holmes, Kyburg, Meerbote, Modrak
Associate Professor Dees
Assistant Professor Uzquiano
Joint Appointment: Professors Carlson, Curren (Chair), Wierenga
Professors Emeriti Eberle, O'Brien, Turbayne

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.  
Computability, incompleteness of arithmetic, metatheory of propositional and predicate logic.

417. Uncertain Inference  
(Same as CSC 417)  
Prerequisite: PHL 110 or equivalent.  
The exploration of various measures of uncertainty proposed in both philosophy and computer science.

418. Philosophy of Mathematics  
Prerequisite: PHL 110 or equivalent.  
A study of the nature of mathematics from a philosophical point of view.

419. Deviant Logic  
Prerequisite: PHL 110 or equivalent.  
The study of "alternative" logics: logics in which more than two truth values are possible, logics designed to accommodate vagueness, logics that allow inconsistencies.

420. Recent Ethical Theory  
Prerequisite: PHL 102 or permission of instructor.  
An examination of the main twentieth-century ethical and 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.

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
Credit—none

Physics and Astronomy

Professors Bigelow, Blackman, Bodek (Chair), Cline, Das, Douglass, Eberly, Ferbel, Forrest, Frank, Gao, Hagen, Melissinos, Orr, Rajeev, Shapir, Slattery, Teitel, Thorndike, Tipton, Watson, Wolf, Wolfs
Associate Professors Demina, Manly, McFarland
Assistant Professors Howell, Quillen, Wu
Adjunct Professor Van Horn
Adjunct Associate Professor Spoonhower
Joint Appointments: Professors Agrawal, Betti, Bocko, Boyd, Foster, McCrory, Meyerhofer, Rothberg, Simon, Stroud, Thomas, Zhong; Research Professor Conwell
Director, Mees Observatory: Forrest
Senior Lecturers/Scientists Auchincloss, Budd, deBarbaro, Ginther, Sakumoto, Zielinski
Visiting Associate Professor Visser
Professors Emeriti Castner, Fulbright, Gove, Helfer, Huizenga, Jacobsen, Knox, Kultan, Okubo, Pipher, Savedoff, Sharpless, Sproull

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 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. Theoretical work on energy migration in photosynthetic systems has a long and distinguished history at Rochester. 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 and low temperature physics, including studies of interfaces in organic semiconductor devices, the spectroscopy of nanostructures, ultrafast dynamics of photoexcited electrons, and electron transport and tunneling in disordered thin metallic and superconducting films. 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 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. The most recent example of which was a joint Ph.D. in physics and electrical engineering.

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 218–282. 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 traineeships.

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**  
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.

**235. Classical Mechanics I**  
*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.

**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 Laboratory 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 Laboratory 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 momentum; perturbation theory and simple scattering theory.

**258. Energy and Environment**  
*Prerequisites: three semesters of physics, two semesters of math.*  
A broad survey of the energy-environment field, for science and engineering concentrators.

**261. Interference and Diffractions**  
*(Same 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.
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, RAD 501)  
Prerequisite: permission of instructor.  
Credit—two hours  
This 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 charged 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 490A)  
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 490B)  
Credit—two hours  
Continuation of 427.

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; lightwave sources such as light-emitting diodes and semiconductor lasers; optical receivers; noise analysis and bit-error rate; coherent, multichannel, and soliton-based communication systems.

439. Nonlinear Optical Spectroscopy
(Same as CHM 459)
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. Nuclear and Particle Physics
(Same as PHY 254)
Describes the properties of nuclei and various models useful for the description of nuclear properties. The models and ideas include the liquid drop model, shell model, collective model, radioactivity, fission, and fusion. Properties of particle interactions with matter are covered and used to develop principles of detections used in nuclear and particle experiments. The physical ideas behind various existing accelerators are discussed. Finally, the fundamental interactions of elementary particles and their constituents are reviewed, with emphasis on issues pertaining to the conservation of quantum numbers and symmetries observed in the high-energy collisions.

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, VanKampen 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 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.

552. Magnetohydrodynamics  
(Same as ME 532)  

Equations of magnetohydrodynamics. Kinematical theory of magnetic field transport; equilibrium and stability; incompressible MHD flows; magnetoacoustic waves; MHD shock waves. Kinetic theory foundations of MHD and selected applications, such as flowmeters, the dynamo problem, solar wind, and sunspots.

553. Laser-Plasma Interactions  
(Same as ME 535)  
Prerequisite: PHY 426 or permission of instructor.  


554. Cosmology  
(Same as AST 554)  

Introduction to cosmology, covering the following broad topics: introduction to the universe, introduction to general relativity, cosmological models and Friedmann-Walker universe, thermodynamics of early universe, particle physics of the early universe, and the formation of large-scale structure.

555. Advanced Topics in Plasma Physics  
(Same as ME 545)  

Course varies year to year. Topics include controlled fusion reactor concepts, including laser fusion, energy in the future, space plasmas, and astrophysical plasma phenomena.
556. Hydrodynamic Stability and Turbulence  
(Same as AST 554)  

557. Plasma Stability  
(Same as ME 534)  
Prerequisite: ME 434 or permission of the instructor.  
Stability of magnetically confined plasma, delta-W formalism, double adiabatic equation, comparison theorem, shear stabilization, minimum-beta fields, resistive instabilities, Tokamak and Mirror stability theory.

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. The course generally has separate sections dealing with diverse topics.

594. Special Topics in Physics II  
See description of 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. The seminar consists of lectures and discussions on various aspects of being an effective teaching assistant, including interactions with undergraduate student body and cross-cultural issues. Members of the faculty discuss topics in their current area of research interest.

598. Teaching Workshop Pedagogy Training  
No credit  
Designed for a student to be a Workshop Leader teaching assistant (TA). Typically, the TA attends the weekly Workshop Leader training meeting that offers specialized support and training in group dynamics, learning theory, and science pedagogy for students facilitating collaborative learning groups for science and social science courses. The TA teaches 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, a lead Workshop Leader teaching assistant (TA) typically attends the weekly Workshop Leader training meeting that offers specialized support and training to develop leadership skills, to foster ongoing communication among faculty members and study group leaders, and to provide an environment for review of study group related issues. Students spend the semester teaching three to four workshops during the spring semester introductory physics courses.

999. Doctoral Dissertation  
No credit  
Writing dissertation.
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.

Introduction to the physics of stars is taken primarily by juniors and seniors majoring in physics and astronomy, physics, optics, or mathematics. The elements of radiative transfer and gas dynamics are presented and applied to the study of the atmospheres of stars. The 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 111 and/or AST 142 is advised.

Introduction to the physical processes in astronomical objects is taken primarily by juniors and seniors majoring in physics and astronomy, physics, optics, or mathematics. Topics include physical processes in the interstellar medium; star formation and molecular clouds; the structure of galaxies; and interaction to cosmology.

403. Experimental Techniques in Astronomy
Prerequisites: the equivalent of PHY 217–218, ME 201, and PHY 227.

This course is an introduction to the tools of modern observational astronomy. We discuss geometrical and physical optics applied to telescopes and astronomical cameras; the physics of light detection at radio, infrared, visible, X-ray, and γ-ray wavelengths; and the instruments and techniques used for observations of faint celestial objects over the full useful range of spectral and angular resolution. The intention is to provide to students the preparation necessary to design, build, and optimize astronomical instruments. However, the material should be useful to anyone who will be using remote-sensing instruments, astronomical or otherwise, or is seeking to understand measurements made with these devices.

442. Galaxies and Cosmology
Prerequisites: the equivalent of PHY 227 and PHY 237; general knowledge of astronomy at the level of AST 142 is assumed.

We begin with an introduction and review of the constituents of the Milky Way Galaxy (see AST 232W), and then address the measurement of the number density of stars with location in the galaxy, the rotation curve, the “missing mass,” and the galactic center. Spiral structure is investigated through density wave theory; stochastic star formation is then addressed. The properties of spiral and elliptical galaxies are cataloged; measurement of rotation curves in external spiral galaxies is then outlined. Active and unusual galaxies, galaxy-galaxy interactions, and galaxy formation are investigated. The structure of the universe including galaxy clustering is probed after discussion of distance determination methods and of the Hubble flow. Some cosmological theories are discussed, as well as observational constraints on those theories, including cosmic background radiation measurements by COBE. Finally, scenarios describing the Early Universe are presented.

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, supernova 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 and Infrared 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 Jackson, Jacobs, Niemi, Phelps, G. Powell, L. Powell
Associate Professors Duggan, Fey, Gamm (Chair), Harris, Johnson, Signorino, Stone
Assistant Professors Clarke, Goemans, Helmke, Kalandrakis, Kayser, Meguid, Primo, Sinclair-Chapman
Adjunct Associate Professor Hauser
Joint Appointments: Professor van Geel
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. Introduction to Statistical Methods
405. Multivariate Statistical Methods
505. Advanced Statistical Methods in Political Science and Policy Analysis

506. Workshop in Quantitative Political Research
Prerequisite: PSC 505 or permission of instructor.
American Politics
510. Political Parties and Elections
511. Public Opinion and Electoral Behavior
512. Voting and Elections
513. Public Opinion and Public Policy
514. Congress as an Institution
515. Legislative Behavior
516. Political Participation

Comparative Politics
550. Comparative Politics Field Seminar
551. Western European Politics
552. Comparative Political Institutions

International Relations
479. War and the Nation State
572. Topics in International Relations
573. Territory and Group Conflict
574. Topics in International Political Economy

Positive Political Theory
407. Mathematical Modeling
408. Positive Political Theory
575. Political Economy I
(See PEC 580)
582. Political Economy II
(See PEC 582)

Political Philosophy
480. Scope of Political Science
482. Art and Politics

Other Offerings
491. Reading Course at the Master's Level
492. Research at the Master's Level

Comparative Politics
555. Democratic Processes
556. Political Economy of Reform
557. Political Institutions

International Relations
576. Modeling International Conflict
578. International Conflict: Theory and History

Positive Political Theory
584. Game Theory
586. Theory of Voting and Elections
588. Theory of Institutions
593. Topics in Positive Political Theory
598. Topics in Political Theory

Political Philosophy
581. Philosophical Foundations of Political Science
583. Culture and Politics

Other Offerings
591. Reading Course at the Ph.D. Level
592. Research at the Ph.D. Level
Center for Visual Science

Professors Aslin, Ballard, Duffy, Feldon, Hayhoe, Ison, Jacobs, MacRae, Makous, Merigan, Paige, Pasternak, Schieber, Williams (Director)
Associate Professors Bavelier, Knill (Associate Director), Pouget, Weliky
Assistant Professors Freedman, Huxlin, Lee, Romanski, Seidman
Adjunct Professors Cox, Krauskopf
Adjunct Assistant Professors Karn, Pelz, I. William
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)
508. Neural Plasticity in Learning and Development
511. Behavioral Methods in Cognitive Science
524. Advanced Problems in Motion Perception and Action
   (Same as BCS 524 and ANA 459)
526. Principles of Eye Design
   (Same as BCS 526 and OPT 448)
528. Special Topics in Vision
   (Same as BCS 528)
536. Sensory Motor Systems
   (Same as BCS 536)
547. Introduction to Computational Neuroscience
592. Neuroscience Journal Readings Course
   (Same as NSC 592)

Visual and Cultural Studies Program

Professors Berlo, Crimp, DiPiero, Duro, Willis
Associate Professor Halle
Assistant Professor Saab
Affiliated faculty: Professors Foster, Gustafson, Michael; Associate Professors Kegl, Seiberling;
   Assistant Professors Nader, Tucker

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*

AH 405. Representing Differences
AH 410. Woman as Image and Text
AH 414. Beyond the Boundaries
AH 459. Women, Cloth, and Culture
AH 460. Cultural Tourism
AH 462. Impressionism and Post-Impressionism
AH 477. The Museum and ‘the Other’
AH 484. Modern Architecture and Urbanism
AH 487. Culture on Display
AH 492. Representing the Modern City
AH 506. Romantic Sublime
AH 507. Rhetoric of the Frame
AH 508. Art and Imitation
AH 512. The Sixties
AH 520. The Politics of Space
AH 525. Contemporary Art and Culture
AH 550. Contemporary Art and Criticism
ANT 426. Culture, Consumption, and Consumerism
ANT 466. Global Culture
ANT 551. Meaning and Emotion in Culture
CLT 405C. French Avant-Garde(s)

* Offerings vary from year to year. Arrangements may be made for directed courses in studio.
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tr>
<td>CLT 411B</td>
<td>French Film: The New Wave</td>
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<tr>
<td>CLT 412</td>
<td>Avant-Garde Film</td>
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<tr>
<td>CLT 412G</td>
<td>Nazi Culture</td>
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<tr>
<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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<td>CLT 481</td>
<td>Popular Film: Sex and Violence</td>
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<td>CLT 481A</td>
<td>Contemporary French Thought</td>
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<td>CLT 481B</td>
<td>Freud, Lacan, and Contemporary Thought</td>
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<tr>
<td>CLT 482</td>
<td>Freud: An Introduction</td>
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<tr>
<td>CLT 482A</td>
<td>Nietzsche and the Nietzscheans</td>
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<td>ENG 437</td>
<td>Marxism and Feminism</td>
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<td>ENG 457</td>
<td>Media Studies</td>
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<td>ENG 458</td>
<td>Feminism, Criticism, and Culture</td>
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<td>ENG 488</td>
<td>Marxist Cultural Theory</td>
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<td>ENG 551</td>
<td>Critical Theory—Foucault</td>
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<td>ENG 542</td>
<td>The African-American Postmodern</td>
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<td>ENG 552</td>
<td>Aesthetics, Identity, Power</td>
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<tr>
<td>ENG 553</td>
<td>Feminist Theory</td>
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<tr>
<td>HIS 482</td>
<td>Topics in Twentieth-Century American Cultural History</td>
</tr>
<tr>
<td>SA 491</td>
<td>Independent Studio</td>
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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)