# Cornell University Announcements Graduate School: Course Descriptions 1972-73

# Cornell University

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# Cornell University

# Graduate Course Descriptions

This catalog is an attempt to combine in one book the listings of most courses of interest to graduate students, including advanced undergraduate courses. The courses are listed according to Fields and frequently include brief descriptions of the topics covered. The listings do not include names of the instructors or times when the courses are offered since this information is available elsewhere in much more up-to-date form (see the appropriate college announcements or the Course and Room Roster issued by the Registrar each term).

Descriptions of the activities encompassed by the various graduate Fields are available in the *Graduate School Announcement.*

## Aerospace Engineering

**7101 Applied Thermal Physics**
Classical thermodynamics, kinetic theory, and statistical mechanics applied to selected areas of research such as high temperature gas reactions, gas lasers, ferromagnetism, etc. Some previous experience with thermodynamics is desirable. Topics covered depend on class interest.

**7102 Gasdynamics**
Strong shock waves and their use in the production and study of high temperature gases. High temperature chemical kinetics and applications. Theory of characteristics including chemical reactions. Experimental techniques.

**7104 Advanced Topics in High Temperature Gasdynamics**
Current topics relating to present engineering practice and/or research interests of the faculty and staff. One or more of the following topics may be included: the physics of lasers; electro-fluid-dynamics; molecular relaxation phenomena; collision cross sections.

**7201 Introductory Plasma Physics**
Particle orbits in electric and magnetic fields, adiabatic invariants, Coulomb scattering, transport phenomena, plasma oscillations and waves, hydromagnetic equations, energy principle and instabilities, controlled thermonuclear research. At the level of Longmire, *Elementary Plasma Physics.*

**7301 Fluid Mechanics**
Cartesian tensors, stress, strain, constitutive equations and the fundamental equations of continua. Boundary conditions. Fluid mechanics, including the effects of viscosity, boundary layer concepts, ideal fluid flow and vorticity.

**7302 Aerodynamics**
Methods of ideal incompressible fluid flow for plane and axisymmetric flows and wings. Acoustics, compressible subsonic and supersonic flow, shock waves, boundary layer, heat transfer, separation.

**7303 Compressible Fluid Flow**
Aerodynamics of compressible fluids. Characteristics for three-dimensional rotational, reacting flows. Supersonic linearized flow theory. Higher order theories and sonic boom. Shock waves and related phenomena.

**7304 Theories of Viscous Flows**
Exact solutions of the Navier-Stokes equations. Small Reynolds number approximations. Boundary layer theory. Stability of laminar flows. Turbulence.

**7305 Hypersonic Flow Theory**
Hypersonic small disturbance theory; blast waves; entropy layers. Newtonian theory and shock layers. The blunt body problem. Viscous and real gas effects.

**7306 Atmospheric Motions**
For students with a background in fluid mechanics. Contents will vary depending on student interest, but the material will emphasize an understanding of atmospheric motions on either a global or local scale.

**7307 Acoustics and Aerodynamic Noise**
Basic acoustics and sound propagation. Generation of noise by surfaces, turbulence and unsteady flows and application to aircraft noise.

**7801 Research in Aerospace Engineering**

**7901 Aerospace Engineering Colloquium**
Lectures by Cornell staff members, graduate students, and visiting scientists.

**7902 Seminar in Aerospace Engineering**
Study and discussion of topics of current interest in aerospace engineering. Participants prepare and deliver reports based on published literature.

**7903 Plasma Physics Colloquium**
Lectures by staff members, graduate students, and outside scientists on topics of current interest in plasma research.

## African and Afro-American Studies

**340 Culture, Politics, and the Black Writer**

**346 African Socialism**

**352 Pan-Africanism and Contemporary Black Ideologies**

**370 Main Currents in African and Afro-American History**

**372 Cultural Life Styles and Social Process in Black Communities**

**420 Politics and Social Organization in the Black Community**

**484 African Liberation Movements**

**490 Seminar in Black History**

**492 Seminar in Advanced Black Literature**

**566 Politics and National Integration in Africa**

**620 Advanced Research Seminar in African and Afro-American History**

**Anthropology 438 Ethnology in Africa**

**Anthropology 520 Ethnolinguistics**

**Anthropology 539 Africa**

**Economics 373-374 Economic Development of the Urban Ghetto**

**Economics 671-672 Economics of Development**

**Education 476 The Urban School**

**English 467 The Afro-American Novel and Its Tradition**

**Government 338 Politics and Modernization**

**Government 349 Political Role of the Military**

**Government 350 Comparative Revolutions**

**History 488 Problems in the History of Brazil**

**History 673-674 Seminar in American Political History and the Antebellum Period**

**History 685-686 Seminar in the History of the American South**

**Linguistics 515-516 Sociolinguistics**

**Sociology 536 Demographic Research Methods**

**Sociology 539 Population in Tropical Africa**

**Center for International Studies 550 Research in Comparative Modernization**

**Center for International Studies 572 Processes of Economic Growth and Development**

## Agricultural Economics

**402 Advanced Farm Business Management**

**403 Cost Accounting for Farm Business Management**

**405 Farm Finance**

**406 Farm Appraisal**

**412 Introduction to Quantitative Methods**

**424 Business Policy**

**441 Food Distribution**

**443 Food Industry Management**

**447 Field Study of Marketing Institutions**

**450 Resource Economics**

**452 Regional Agricultural Studies**

**464 Economics of Agricultural Development**

**507 Introduction to Research in Agricultural Economics**

**508 Production Economics with Quantitative Applications**

**510 Econometrics I**

**511 Econometrics II**

**512 Quantitative Methods I**

**513 Quantitative Methods II**

**540 Marketing Research**

**541 Food Merchandising**

**550 Economic Analysis of Public Resource Investments**

**552 Special Problems in Land Economics**

**560 World Food Economics**

**626 Seminar in Agricultural Cooperation**

**637 Administration of Public Agricultural Programs**

**641 Marketing and Pricing Efficiency**

**642 Social Responsibility in Marketing**

**650 Workshop on Resource Economics**

**651 Seminar on Agricultural Policy**

**652 Readings in Philosophy**

**665 Seminar in Latin American Agricultural Policy**

**668 Seminar in Economics of Agricultural Development**

**669 Seminar in Agriculture and Economic Planning Models**

**690 Seminar in Agricultural Economics Extension**

## Agricultural Engineering

**421 Introduction to Environmental Pollution**
A general course dealing with the impairment of the environment by the wastes of man. The causes and effects of air, water, and soil pollution will be discussed Fundamental factors underlying waste production, abatement, treatment, and control. A selected number of wastes from urban, rural, and industrial areas will be used to illustrate the factors.

**461 Agricultural Machinery Design**
The principles of design and development of agricultural machines to meet functional requirements. Emphasis is given to computer-aided analysis and design, stress analysis, selection of construction materials, and testing procedures involved in agricultural machine development. Engineering creativity and agricultural machine systems are also stressed.

**462 Agricultural Power**
Utilization of internal combustion engine energy and other forms of energy in agriculture. Basic theory, analysis, and testing of internal combustion engines for use in farm tractors and other agricultural power applications. Specific study of tractor transmissions, Nebraska Tractor Tests, and soil mechanics related to traction and vehicle mobility. Economic and human factors in power use and application will be considered.

**463 Processing and Handling Systems for Agricultural Materials**
Processes such as size reduction, separation, metering, and drying will be studied. Psychrometrics, fluid flow measurement, and an introduction to dimensional analysis and controls for agricultural applications are included. Problem solutions will employ both the analog and digital computers. It is preferred that the student know how to write programs to utilize the digital computer prior to enrolling in the course.

**471 Soil and Water Engineering**
The application of engineering principles to soil and water control in agriculture. Includes design and construction of drainage systems and farm ponds, design and operation of sprinkler systems for irrigation.

**481 Agricultural Structures**
Synthesis of complete farmstead production units including structures, equipment, and management techniques. Integrated application of structural theory, thermodynamics, machine design, and methods engineering to satisfy biological and economic requirements.

**491 Highway Engineering**
Emphasis is on secondary roads in study of economic considerations in road system improvement, road improvement planning and programming, road location and geometric design, engineering soil characteristics and classification, design of roadbed thickness, drainage, stabilization methods and materials, dust palliatives, wearing surfaces.

**501 Similitude Methodology**
Similitude methodology, including the use of dimensional analysis to develop general equations to define physical phenomena, model theory, distorted models, and analogies, with an introduction to a variety of applications in engineering. Problem solutions will employ both analog and digital computers. It is preferred that the student know how to write programs to utilize the digital computer prior to enrolling in the course.

**502 Instrumentation**
Emphasis is on the application of instrumentation concepts and systems to physical and biological measurements. Characteristics of instruments, application of operational amplifiers and transistors for signal conditioning and interfacing, shielding and grounding; transducers for measurement of force, pressure, displacement, velocity, acceleration, temperature, light, and flow; and data acquisition systems, including telemetry.

**504 Biological Engineering Analysis**
Engineering problem-solving strategies and techniques will be explored. The student will solve several representative engineering problems which inherently involve biological properties. The mathematical modeling will emphasize problem formulation and interpretation of results. The student's knowledge of fundamental principles will be extensively utilized. Principles of feedback control theory will be applied to biological systems.

**505 Solid Waste Management (Civil Engineering 2530)**
Study of municipal, industrial, and agricultural solid wastes. Emphasis on waste characteristics, methods of treatment and disposal, and interrelationships with the air, water, and land environment. Discussion of economic and political aspects. Enrollment also open to nonengineering students.

**506 Industrial Waste Management (Civil Engineering 2531)**
Legal aspects, assimilatory capacity of receiving waters, waste sampling and analysis, treatment processes, waste reduction possibilities, waste quantity and quality, reuse and recovery, joint industry-municipal treatment of wastes, sewerage service charges, and case studies. Emphasis on liquid industrial wastes.

**551-552 Agricultural Engineering Project**
Both terms required for M.Eng. (Agr.) degree. Comprehensive design projects utilizing real engineering problems to represent fundamentals of agricultural engineering design. Emphasis on formulation of alternate design proposals, including economics and nontechnical factors, and complete design of the best alternative.

**601 Agricultural Engineering Seminar**
Fall term required of all graduate students majoring in the Field. Presentation and discussion of research and special developments in agricultural engineering and other fields.

**602 Power and Machinery Seminar**
Study and discussion of research and new developments in agricultural power and machinery.

**603 Soils and Water Engineering Seminar**
Study and discussion of research on selected topics in irrigation, drainage, erosion control, and agricultural hydrology.

**604 Agricultural Structures Seminar**
Study and discussion of farmstead production problems with emphasis on biological, economic, environmental, and structural requirements.

**605 Agricultural Waste Management Seminar**
Study and discussion of the management of agricultural wastes with emphasis on the physical, chemical, biological, economic, and aesthetic considerations.

**606 Biological Engineering Seminar**
The interaction between engineering and biology will be examined, especially the environmental aspects of plant, animal, and human physiology, in order to improve communications between engineers and biologists.

*Note:* For information on courses designed for teachers of vocational agriculture in the areas of farm electrification, farm welding, small gasoline engines, and farm tractors, consult the *Summer Session Announcement.*

# Agronomy

**401 Geography and Appraisal of Soils of the Tropics**

**402 Chemical Methods of Soil Analysis**

**403 Soil Organic Matter and Organic Soils**

**404 Forest Soils**

**405 Soil Mineralogy**

**406 Use of Soil Information and Maps as Resource Inventories**

**407 Soil Physics, Lectures**

**408 Soil Physics, Laboratory**

**410 Microbial Ecology**

**422 Tropical Agriculture**

**450 Special Topics in Soil Science**

**451 Special Topics in Field Crop Science**

**461 Regional Agronomy Studies**
A three-week field study trip takes place during the August preceding the course.

**481 Special Studies in Soils of the Tropics**

**501 Soil Chemistry**

**503 Morphology, Genesis, and Classification of Soils**

**506 Advanced Soil Microbiology**

**507 Soil Physics, Lectures**

**513 Crop Ecology**

**514 Grasslands and Grassland Research**

**522 Special Studies in Tropical Agriculture**
May include field laboratory trip to tropical area during January intersession.

**524 Soil Fertility, Advanced Course**

**550 Research Orientation and Perspective**

**560 Research in Soil Science**

**561 Research in Field-Crop Production**

**690 Agronomy Seminar**
Required of graduate students majoring or minoring in the Field.

**691 Soil Science Seminar**
Required of students whose major or minor subject is soil science.

**692 Crop Science Seminar**
Required of students whose major or minor subject is crop science.

## Meteorology

The following courses carry Meteorology numbers.

**411 Basic Theoretical Meteorology I**

**412 Basic Theoretical Meteorology II**

**417 Physical Meteorology**

**438 Atmospheric Pollution**

**449 Physics of Clouds, Rain, and Rainmaking**

**550 Special Topics in Meteorology and Climatology**

**562 Research in Meteorology**

**691 Seminar in Meteorology**

# Animal Breeding

**Animal Science 420 Quantitative Animal Genetics**

**Animal Science 421 Seminar in Animal Genetics**

**Animal Science 422 Research Techniques in Quantitative Animal Genetics**

**Animal Science 520 Experimental Methods in Quantitative Genetics and Animal Breeding**

**Animal Science 620 Seminar in Animal Breeding**

**Poultry Science 419 Animal Cytogenetics**

**Poultry Science 420 Poultry Genetics**

# Animal Science

**400 Livestock Production in Warm Climates**
Deals with factors inhibiting efficient livestock production and some of the potential roles animals can fulfill as sources of food, power, and fiber in the tropical areas of the world.

**401 Special Studies on Problems of Livestock Production in the Tropics**
Eleven-day field trip to Puerto Rico during winter intersession for viewing problems in livestock and related agricultural production and research dealing with forage and phases of animal science: preregistration by December 1 required. During the term, in-depth studies will be made on some of the problems influencing livestock in the tropics.

**403 Forages of the Tropics for Livestock Production**
A review of the naturalized grasslands, sown pastures, and fodders of the tropics and their utilization for grazing and livestock feeding. Agronomic characteristics of grasses and legumes, pasture management, conduct of grazing trails, and systems of management for livestock will be considered. Nutritive value of tropical forages and digestibility studies are included.

**410 Principles of Animal Nutrition**

**411 Principles of Animal Nutrition, Laboratory**

**420 Quantitative Animal Genetics**
A consideration of the problems involved in the improvement of animals, especially farm animals, through the application of the theory of quantitative genetics with emphasis on the selection index. An optional (arranged) hour gives an introduction to methods of research in quantitative genetics and animal breeding.

**422 Research Techniques in Quantitative Animal Genetics**
An introduction to methods of research in quantitative genetics and animal breeding including estimation of heritability, repeatability, and genetic and phenotypic correlations.

**424 Animal Genetics**
Principles of genetics; sex determination and sex linkage; inheritance of characteristics in domestic animals with special reference to lethal genes, genetic resistance to disease, and quantitative characters; progeny testing, genetic relationships and inbreeding. For veterinary students only.

**427 Fundamentals of Endocrinology**
A general course in the physiology of the endocrine glands and the roles played by each hormone in the regulation of normal body processes.

**430 Livestock Improvement through Artificial Breeding**

**440 Advanced Reproductive Physiology**
Subjects may include neuroendocrinology, biochemistry related to reproductive physiology, or biochemistry of the gametes.

**451 Physiology and Biochemistry of Lactation**
An advanced course in the anatomy of the mammary gland, the physiological mechanisms of milk secretion, and the biochemical synthesis of milk constituents in laboratory and farm animals.

**490 Meat Technology**
The character of muscle as a food, muscle structure, meat product formulations and production, methods for meat product quality control, product testing and improved meat packaging. The basic principles of meat preservation, processing, and meat product development through laboratory demonstration and practice in the pilot meat plant in Morrison Hall.

**500 Research**

**505 Biochemistry of Forages and Their Utilization**

**511 Laboratory Work in Animal Nutrition**

**513 Forage Analysis**

**520 Experimental Methods in Quantitative Genetics and Animal Breeding**
Estimation of genetic and environmental parameters required to design efficient selection programs. Particular emphasis is given to interpretation of experimental and

survey data with unequal subclass numbers and to prediction of genetic progress resulting from alternative selection methods.

**601 Seminar in Animal Science**

**610 Seminar in Animal Reproduction and Endocrinology**

**619 Seminar in Animal Nutrition**

**620 Seminar in Animal Breeding**

**Biological Sciences 414 Mammalian Physiology**
See listing under Field of Physiology.

**Advanced Nutrition Series**
See listing under Field of Nutrition.

## Poultry Science

The following courses carry Poultry Science numbers.

**419 Animal Cytogenetics**
The causes and phenotypic effects of chromosomal aberrations in higher animals, as these affect embryo development, postnatal growth, and behavior. Attention is given to genetic, physiological, and environmental variables that may cause meiotic and mitotic abnormalities. Demonstrations include cytogenetic, cytochemical, and cytophotometric techniques.

**420 Poultry Genetics**
A survey of inherited characters in domestic birds, cytology, linkage, inbreeding, hybrid vigor, resistance to disease, physiology of avian reproduction, infertility, embryonic mortality, and avian endocrinology.

**425 Comparative Physiology of Reproduction of Vertebrates**
Endocrinology of reproduction, interactions between endocrine and nervous systems. Students have the opportunity to design and execute experiments.

**440 Anatomy of the Fowl**
Lectures and laboratory designed to acquaint the student with the anatomy of the fowl.

**450 Poultry Meat and Egg Technology**

**Advanced Nutrition Series**
See listing under Field of Nutrition.

**511 Special Topics in Nutrition**
For students desiring experience in conducting independent research projects in poultry nutrition.

**609 Seminar in Poultry Biology**
A survey of recent literature and research in poultry biology.

# Anthropology

**412 Ethnographical Theory**

**413 History of Anthropology in the United States**

**418 Ethnohistory**

**419 Meso-American Thought and Culture**

**424 Myth, Ritual, and Symbol**

**451 Archaeology and the Humanities**

**452 Archaeology and the Sciences**

**471 Physical Anthropology Laboratory**

**472 Physical Anthropology Laboratory**

**497-498 Topics in Anthropology**

**501 Proseminar: The Scope of Anthropology**

**502 The Design of Field Research**

**503 Human Biology and Cultural Behavior**

**507, 508 Special Problems in Anthropology**

**512 History of Anthropological Thought**

**513 Contemporary Anthropological Theory**

**514 Applied Anthropology**

**517 Conceptual Systems in Anthropology**

**518 Cultural Processes: Role "Theory" and Cultural Change**

**520 Ethnolinguistics**

**523 Social Systems: The Anthropology of Face-to-Face Interaction**

**526 Problems in Economic Anthropology**

**528 Political Anthropology: Culture and Politics**

**530 North America**

**531 Middle America**

**532 South America: Lowland Research**

**534, 535 Southeast Asia: Readings in Special Problems**

**537 Islamic Sects and Religious Movements.**

**540 South Asia**

**541, 542 South Asia: Readings in Special Problems**

**543 China**

**545 Japan**

**548 Comparative Studies in Complex Societies: Agrarian Civilizations**

**564 Problems in Archaeology: The Andes**

**565 Archaeology: Agriculture and Civilization**

**567 Origins of Meso-American Civilizations**

**573 Human Adaptation**

**575 Physical Anthropology: History and Theory**

**576 Physical Anthropology: Problems, Methods, and Theory**

**578 Paleoanthropology: South Asia**

**598-599 The Teaching of Anthropology**

**601-602 Field Research**

# Applied Mathematics

See listings under the Fields of Aerospace Engineering Applied Physics, Astronomy and Space Sciences, Chemistry, Computer Science, Electrical Engineering, Mathematics, Mechanical Engineering, Operations Research, Physics, and Theoretical and Applied Mechanics.

# Applied Physics

The following courses carry Engineering Physics numbers.

**8051, 8052 Project**
Informal study under direction of a member of the staff. The objective is to develop self-reliance and initiative, as well as to gain experience with methods of attack and with overall planning in the carrying out of a special problem related to the student's field of interest.

**8090 Informal Study in Engineering Physics**
Laboratory or theoretical work in any branch of engineering physics under the direction of a member of the staff.

**8123 Statistical Thermodynamics**
Quantum statistical basis for equilibrium thermodynamics, canonical and grand canonical ensembles and functions. Thermal cycles and laws of thermodynamics, concepts of temperature, entropy, free energy, etc. Differential thermodynamic relations. Quantum and classical ideal gases and paramagnetic systems, Fermi-Dirac, Bose-Einstein, and Maxwell-Boltzmann statistics.

**8124 Statistical Physics**
Statistical physics of electromagnetic radiation, phonons, metals, and low temperatures. Imperfect gases, molecules, phase transitions, and chemical equilibrium. Rate processes, fluctuation, electrical noise, dissipative processes, and elementary kinetic theory, with an introduction to the master equation, and the Boltzmann transport equation.

**8133 Mechanics of Particles and Solid Bodies**
Newton's laws, harmonic oscillator. Fourier series and Green's function solutions. Lagrange equations. Hamiltonian formalism, central force motion, orbits, scattering, cross-sections. Many particle dynamics, Lagrangian formulations, Lorentz transformation.

**8134 Mechanics of Continua**
Mechanics of continua, equilibrium, propagation of sound waves. Elasticity, torsion, shear, bending stresses.

**8155-8156 Intermediate Electrodynamics**
Vector calculus. Electrostatic fields, Laplace and Poisson equations and boundary value problems, dielectrics, magnetostatic fields, permeable media. Maxwell's equations and wave equations. Waves in free space and in media. Application of Maxwell's equations to wave guides, plasmas, and magnetohydrodynamics. Special relativity. Application of the wave equation to radiation: antennas, scattering of light, reflection, diffraction, polarization, and dispersion. At the level of (for first term) *Foundations of Electromagnetic Theory* by Reitz and Milford, *Introduction to Electromagnetic Theory* by Owen, and (for the second term) *Classical Electromagnetic Radiation* by Marion. Primarily for students of engineering.

**8161 Introductory Quantum Mechanics**
A first course in the systematic theory of quantum phenomena. Topics will include illustrative solutions of the Schroedinger equation, angular momentum, spin, and the exclusion principle, perturbation theory, and introduction to symmetries and the Dirac formulation. The course is similar to Physics 443. At the level of *Introduction to Quantum Theory,* by Park, and Volume III of the *Feynman Lectures on Physics.*

**8205 Electrical and Magnetic Properties of Engineering Materials**
Electrical properties of semiconductors. Metallic alloys. Ferromagnetic materials. Superconductivity. Optical and dielectric properties of insulators and semiconductors. At the level of Kittel, *Introduction to Solid State Physics;* Chikazumi, *Physics of Magnetism;* Lynton, *Superconductivity;* Livingston and Schadler, *The Effect of Metallurgical Variables on Superconductivity Properties.*

**8211 Principles of Diffraction**
Production of neutrons, x rays, absorption, scattering. Compton effect. Diffraction from periodic lattices, crystal symmetry, single crystal and powder techniques. Fourier methods, thermal vibration and scattering, diffraction from liquids and gases, introduction to dynamical diffraction of x rays and electrons, extinction phenomena and perfect crystals. Selected experiments in diffraction.

**8212 Selected Topics in Diffraction**
Dynamical diffraction: Ewald-von Laue theory of dynamical diffraction applied to x rays and electrons. Currently developing theory and application to defects in solids. Phenonema investigated via diffuse scattering: phonons, measurement of dispersion curves, frequency spectrum, Debye temperatures, vibrational amplitudes. Order-disorder phenomena: short- and long-range order, Guinier-Preston zones. Selected topics of current interest related to x ray, neutron, and electron diffraction, with contributions from several members of the faculty. Offered jointly with Materials Science and Engineering.

**8252 Selected Topics in Physics of Engineering Materials**
Seminar-type discussion of special topics such as plastic and rheological properties, dielectric and magnetic behavior, semiconductors, radiation damage, etc. Emphasis on interpretation of the phenomena in light of modern theories in physics of solids and liquids and their impact on the engineering applications. Current literature is included in the assignments. Primarily for candidates for Master of Engineering (Engineering Physics).

**8261 Kinetic Equations (Electrical Engineering 4661)**

**8262 Physics of Solid Surfaces**
An introductory critical review of advances in the theory of the solid state related directly to surface phenomena. Thermodynamics of surface phases, atomistic theory of surfaces, and dynamics of interaction of electrons, ions and atoms with surfaces. Reference is made to application of the theory to surface and interface phenomena in metals, insulators and semiconductors, as much as possible. At the level of *Advances in Solid State Physics,* ed. Seitz and Turnbull. (Offered jointly with Materials Science and Engineering.)

**8501 Physics of Atomic and Molecular Processes**
An introduction to the basics of contemporary problems in the physics of atomic and molecular processes, including atomic structure, chemical bonding, radiation resonance processes, and elastic and inelastic collisions. At the level of Blokhintsev, *Quantum Mechanics* and the final chapters of Park, *Introduction to Quantum Mechanics.*

**8505 Topics in Statistical Physics**
Selected topics of current research interest in statistical physics. In 1971 these included time correlation functions and collective motion in disordered systems, dynamical phenomena in the neighborhood of critical points, and statistical theory of turbulence. A formalism using memory functions and projection operators originated by Zwanzig and extended by Mori will be systematically presented at the beginning of the course and applied to the first two topics.

**8601 Photosynthesis**
A detailed study of the process by which plants use light in order to grow, emphasizing physical and physicochemical aspects of the problem.

**8603 General Photobiology**
An introduction to biological applications of optics and a study of the major interactions between light and living matter as encountered in photosynthesis, vision, regulation of physiology and development, bioluminescence, and damage by ultraviolet and visible light.

**8901 Issues and Methods in Applying Science**
Designed to offer graduate students in the physical sciences, engineering, business, or social science an introduction to the issues, methods, and problems involved in the application of physical science in "mission-oriented" research, development, industrial techonlogy,

and engineering, and in technological problems of contemporary society. Presented in seminar style with visiting lecturers, discussions, and case studies.

## Architecture

**134 Seminar: Urban Housing Developments**
Concentrates on large-scale housing developments, particularly in relation to size, density, and problems of infrastructure.

**136 Seminar: Outer City Development**
Environmental design issues in development of areas peripheral to and between central cities; a survey and analysis of alternative spatial models for structuring 'outer city' development.

**171-172 Problems in Architectural Design**

**173 Thesis or Research in Architectural Design**

**181-182 Problems in Urban Design**

**183 Thesis or Research in Urban Design**

**191-192 Problems in Regional Design**

**193 Thesis or Research in Regional Design**

**322 Introduction to Recent Design Aids**
Quantitative and qualitative methods of problem solving.

**323 Computer Applications**
Designed to acquaint the student with the current uses and potentials of electronic computers in the architectural profession. No prior knowledge of computers is assumed. Topics will include basic principles and logic of computing systems, computer programming (CUPL and FORTRAN), architectural planning models, examples of linear programming problems, computer graphics, and data processing.

**467-468 Informal Study in the History of Architecture**

**473 Seminar in Medieval Art and Architecture**

**476 Seminar in Renaissance Architecture**

**477 Seminar in Baroque Architecture**

**478 Seminar in the History of American Architecture**

**479 Seminar in the History of Modern Architecture**

**488 Problems in Modern Architecture**

**491-492 Thesis in Architectural History**

**497-498 Dissertation in Architectural History**

**672 Seminar in Industrialized Building**

**771 Visual Perception and Architecture**
A study of the visual perception of space and architecture. Discussions of the theories of perception, the problem of the nature of visual depth, the constancy of the characteristics of perceived objects in relation to geometric space, and other related topics.

**781-782 Architectural Science Laboratory**
Projects, exercises, and research in the architectural sciences.

**791-792 Thesis or Research in Architectural Science**

## Art

**390 Graduate Painting**
The core studio course for the first three terms of graduate study in painting.

**392 Graduate Printmaking**
The core studio course for the first three terms of graduate study in the graphic arts.

**393 Graduate Sculpture**
The core studio course for the first three terms of graduate study in sculpture.

**396 Graduate Thesis**
For graduate students in their last term in the programs in painting, sculpture, and graphics.

**398 Seminar in Art Criticism**
A study of critical opinions, historical and modern, and their relation to problems in the theory of art. Three terms required of M.F.A. candidates.

## Asian Studies

**501-502 Southeast Asia**
A graduate-level survey of the cultures and history of Southeast Asia covering the pre-European, colonial, and postcolonial periods, but with particular emphasis on postwar developments and contemporary problems; will occasionally focus on a problem common to the area as a whole, but usually deals with a different country of Southeast Asia each term.

**591-592 Seminar: Field Research**
Field research seminars for selected advanced studies are conducted in South Asia, Southeast Asia, Hong Kong, Taiwan, or Japan by staff members who are themselves working in these areas.

**676 Southeast Asian Research Training Seminar**
Open only to advanced graduate students preparing for field work in Southeast Asia.

## Astronomy and Space Sciences

**431 Introduction to Astrophysics I**
How is astronomical information gathered and what are the major unsolved problems of modern astrophysics? How are cosmic distances measured and how do we determine the masses of cosmic objects? How do the many objects in the universe interact? How do cosmic gases behave in the atmosphere of planets and in the interstellar and in the intergalactic medium? How are stars formed? How do relativistic particles behave?

**432 Introduction to Astrophysics II**
How does the propagation of electromagnetic waves through the interstellar medium depend on large scale magnetic fields, and on the density of matter? What is the origin of cosmic rays? Where do stars find the energy they pour out as radiation? How do stars alter the nuclear composition of the universe as time evolves, and what are the large-scale evolutionary patterns in the cosmos? What are the astrophysical conditions conducive to life and how should we communicate with extraterrestrial civilizations?

**509 Theory of Gravitation**
Fundamental properties of the gravitational interaction. Review of special relativity, differential geometry, Einstein's and other theories of gravity, and experimental tests. At the level of *Gravitation* by Misner, Thorne, and Wheeler.

**510 Cosmology and Relativistic Astrophysics**
Application of gravitational theory to the description of the content and structure of the universe in the large. Topics treated include cosmology, relativistic stellar structure, gravitational collapse, and gravitational waves. At the level of *Gravitation* by Misner, Thorne, and Wheeler.

**520 Observational Radio and Infrared Astronomy**
Radio astronomy telescopes and electronics, basic antenna theory, observing procedures and data analysis,

and concepts of interferometry and aperture synthesis. Radar astronomy techniques. Infrared atmospheric windows, detectors, spectrometers; observations from high-altitude platforms.

**521 Radio and Infrared Astronomy: Interstellar Medium, Pulsars, Galaxies, Quasars**
Thermal and nonthermal radiation processes. Interstellar emission, reflection, and dark nebulae. Planetary nebulae, novae, supernovae shells and pulsars. Galactic 21-cm emission, galactic structure and kinematics. Emission from normal and abnormal galaxies. Theories of quasi-stellar objects. Universal background radiation. Cosmological models.

**530 Nuclear Astrophysics**
Discussion of abundances and other observations relevant to the origin of the elements, derivation of nuclear reaction rates, stellar energy generation and synthesis processes, and big-bang and other high-temperature synthetic processes. At the level of *Principles of Stellar Evolution and Nucleosynthesis* by Clayton. It is desirable that Astronomy 560 and 530 form a two-course sequence.

**550 Radiative Transfer, Stellar and Solar Atmospheres**
Formulation and solutions of the equation of radiative transfer. Convection. Opacity sources. Limb effects. Structure of the sun's visible surface. Stellar spectra and the comparison of theory and observation. Motions in stellar atmospheres.

**560 Theory of Stellar Structure and Evolution**
Summary of observational facts; dimensional analysis; nuclear reactions in stars; models for static and evolving stars; very massive objects and general relativity; white dwarfs and neutron stars.

**570 Physics of the Planets**
Physics and chemistry of planetary atmospheres, surfaces, and interiors; the roles of convective, conductive and radiative transport; optical, infrared, radio, radar, and space-probe information; applications to exobiology and to the earth as a planet.

**571 Planetary Rotations, Tides, and Physics of Interiors**
Seismic waves, free oscillations, equilibrium tides, gravity and the figure of the planet, rotation of the earth, global tectonics, dynamics and evolution of the earth-moon system, Roche's limit, satellite libration, spin-orbit coupling, commensurabilities, small bodies in the solar system, theories of origin of the solar system.

**575 Motions in Planetary Atmospheres**
The equations of motion. Scaling and geophysical approximations: hydrostatic, quasigeostrophic, Boussinesq, Hadley circulations. Barotropic and baroclinic instability. The role of eddies in the terrestrial atmosphere. Observation and theory for the other planets.

**579 Celestial Mechanics**
Gravitational potential of the earth; two-body, three-body, and restricted three-body problems; Jacobi's integral, Hill curves, libration points and stability, Lagrange's planetary equations; effects of planetary oblateness, atmospheric drag, and solar radiation on satellite orbits; spacecraft orbital transfer and orbital maneuvers.

**620 Seminar: Advanced Radio Astronomy**
Advanced theory in high energy astrophysics and data accumulation and processing methods.

**633 Infrared Astronomy**
Techniques of modern infrared astronomical observation; emission mechanisms of cosmic infrared radiation; infrared observations of planets, stars, nebulae, galaxies, and cosmic background radiation.

**640 Advanced Study and Research**
Upon sufficient demand, guided reading and seminars will be arranged from time to time on topics not currently covered in regular courses.

**671 Special Problems in Planetary Astronomy**

**672 Seminar: Planetary Studies**

**673 Seminar: Current Problems in Planetary Fluid Dynamics**

**675 Solar System Magnetohydrodynamics**
Interaction between the magnetosphere and the solar wind, the acceleration and drift of energetic particles in the magnetospheres of planets, the precipitation of particles and the aurora, and magnetic and ionospheric storms.

**680 Seminar: Cosmic Rays and High Energy Astrophysics (Physics 680)**

**699 Seminar: Current Problems in Theoretical Astrophysics**
This course will deal with the latest problems in theoretical astrophysics and will therefore change content from year to year. Students may wish to take this course more than once for credit.

# Biochemistry

All courses carry Biological Sciences numbers.

**531-532 Intermediate Biochemistry, Lectures**
The major areas of biochemistry will be covered in some detail. This course is appropriate for students who have previously had a one-semester introductory biochemistry course. Fall term: proteins, enzymes and the nature of enzymatic catalysis; carbohydrate metabolism; nitrogen metabolism. Spring term: energetics; lipid metabolism; biosynthesis of informational macromolecules.

**533 General Biochemistry, Laboratory**
Selected experiments on carbohydrates, proteins, amino acids, and metabolism (cellular particulates, kinetics, general enzymology) will be given to illustrate basic biochemical principles. The course will emphasize the quantitative aspects rather than qualitative identification.

**536 Advanced Biochemistry Methods, Laboratory**
After formal instruction on research techniques in biochemistry and molecular biology, students will do research work in the laboratory of three different professors chosen by the students.

**631, 632 Research Seminar in Biochemistry**
Required of all graduate students majoring in biochemistry except first-year students.

**633-638 Advanced Biochemistry**
Lectures and seminars on specialized topics, three topics per term. May be repeated for credit. The following fields will be covered. (Each field is divided into three related topics.): Enzyme Structure and Mechanism of Action (Fall 1972, 1974); Aspects of Protein and Nucleic Acid Synthesis (Spring 1973, 1975); Structure, Function, and Synthesis of Biological Membranes (Fall 1973, 1975); Aspects of Metabolic Pathways and Their Control (Spring, 1974, 1976). The topics for the academic year 1972–73 are as follows:

*Enzyme Structure and Mechanism of Action*

**633 Aspects of Hemoglobin Structure and Function**

**635 (Topic to be announced)**

**637 Control Mechanisms in Protein Biosynthesis**

*Aspects of Protein and Nucleic Acid Synthesis*

**634 Molecular Regulation of Enzyme Activity**

**636 Regulation of Intermediary Metabolism**

**638 Nucleic Acids**

## Botany

All courses carry Biological Sciences numbers unless otherwise noted.

**340 Plant Physiology**

**342 Plant Physiology (Laboratory)**

**344 Biology of the Algae**

**345 Plant Anatomy**

**347 Cytology**

**349 Plants and Man**

**371 Evolution and Taxonomy of Vascular Plants**

**440 Cytogenetics**

**441 Plant Growth and Development**

**444 Morphology of Lower Vascular Plants**

**446 Morphology of Higher Vascular Plants**

**448 Paleobotany**

**463 Plant Ecology**

**464 Evolution and Ecology of Vascular Plants**

**543 Plant Physiology, Advanced Laboratory**
An introduction to some modern methods in experimental plant biology.

**545 Physical Approaches to Problems of Photosynthesis**
Emphasis is on physical and photochemical mechanisms and physical experimental approaches. Photosynthetic organisms, their photochemical apparatus, metabolic pathways and mechanisms for energy conversion; descriptive introduction to the physics of excited states in molecules and molecular aggregates; optical and photochemical properties of chlorophyll and of the living photosynthetic tissue; contemporary investigations of the photosynthetic mechanisms. At the level of *Molecular Physics in Photosynthesis* by Clayton.

**547 General Photobiology**
A survey of systems of current interest in photobiology, including photosynthesis, bioluminescence, vision, photoperiodism, and the action of ultraviolet on nucleic acids. Physical concepts and methodologies are emphasized.

**548 Plant Physiology: Aspects of Metabolism**
Selected areas of plant biochemistry will be reviewed in the context of the plant life cycle and responses to the environment. Probable topics include: metabolism and storage function of lipids, carbohydrates, organic acids; proteins and pigments; nitrogen and sulfur assimilation; hormone metabolism; respiration, photosynthesis, development and replication of mitochondria and chloroplasts; cell wall composition and properties. Emphasis will be on operation of control mechanisms.

**549 Plant Physiology: Transport of Solutes and Water**
An advanced course dealing with the transport of ions, water, and organic materials in plants. Mechanisms of ion transport. Relationships between ion transport and metabolism. Ion uptake and transport in higher plants. Phloem transport. Water relations of single cells and whole plants. Water relations of crops and natural communities.

**645 Current Topics in Plant Physiology**
Seminar reports by graduate students on current literature in experimental plant physiology or related areas.

**647 Special Topics in Plant Taxonomy**
A series of four topics, one presented each term, designed to provide professional background. *Families of Tropical Phanerograms.* The families of flowering plants encountered solely or chiefly in tropical regions will be considered with the aim of providing basic points for recognition and understanding of the diversity and relationships in these families for the student venturing into the tropics. *Literature in Taxonomic Botany.* A survey of the basic reference works in taxonomy from the pre-Linnaean literature drawn on by Linnaeus to contemporary publications, with comments on the peculiarities of the books (when appropriate), and on publication dates, typographic devices, and intricacies of bibliographic citation. *Nomenclature.* An analysis of the International Code of Botanical Nomenclatures and its application to various plant groups. *Biosystematics.* A consideration of biosystematic approaches to taxonomy, including chemical, numerical, cytological and statistical methodologies as well as a review of classic studies.

**663 Seminar in Evolution and Ecology of Vascular Plants**
An examination of primary problems concerned with the classification, evolution, and environmental relationships of vascular plants.

**Plant Pathology 309 Comparative Morphology of Fungi**

See also Ecology and Evolutionary Biology 564, 665, 666, 667, 668; Agronomy 513; Plant Breeding 505; Plant Pathology 508, 579, 599, 649; Pomology 504.

# Business and Public Administration

## Managerial Economics

**124A Microeconomics for Management**

**124B Macroeconomics for Management**

**375 Economic and Business History**

**379 Economic Evaluation of Capital Investment Projects**

**381 Topics in United States Economic Policy**

## Organization Theory and Behavior

**120 Organization Theory and Behavior**

**121 Personnel Administration and Human Relations**

**500 Human Relations in Administration**

**502 Organizational Behavior and Administration**

**503 Business and Industrial Personnel**

**901 The Role of the Individual in Technological Society**

**902 Seminar in Organization Theory**

**903 Administrative Problems of Public Organizations**

**904 Corporate Organization and American Society**

**907 Special Topics in Organizational Theory and Behavior**

## Quantitative Analysis for Administration

123 Quantitative Methods for Management

125 The Computer and Decision Making

456 Bayesian Decision Theory

600 Introduction to Probability Theory (Industrial Engineering 9460)

601 Introduction to Statistical Theory (Industrial Engineering 9470)

602 Operations Research I (Industrial Engineering 9522)

604 Operations Research II (Industrial Engineering 9523)

605 Multidimensional Measurement and Scaling

950 Introduction to Management Information Systems

951 Introduction to Computer Systems Analysis

## Finance

128 Corporate Financial Management

426 Short-Term Financial Management

427 Investment Management

429 The Economics of Securities Markets

430 Money and Banking

433 Seminar in Organized Markets

906 Seminar on Federal Tax Policy and Government Finance

## International Development

624 Introduction to International Economic Relations

627 American Business Operations Abroad

629 Administration of Public Operations Abroad

631 Seminar in Political Development and Social Change (Government 537)

635 The Environment of the Economic Activity in Postwar Europe (Economics 327)

636 Special Topics in International Finance (Economics 666)

637 Workshop in Money, Finance, and International Monetary Relations

638 Tutorial in Export Promotion

640 Science, Technology, and International Relations

## Business and Public Policy

129 Institutions and Values in Contemporary Society

200 Business Policy

202 Business Enterprise and Public Policy

308 Law of Business Associations

309 Advanced Business Law

625 International Business Policy

## Accounting

122 Managerial Accounting

300 Intermediate Accounting

301 Advanced Accounting

302 Managerial Cost Accounting

303 Seminar in Financial Policy and Managerial Accounting

304 Seminar in Financial Accounting

305 Introduction to Taxation Affecting Business and Personal Decision Making

## Marketing

126 Marketing Management

475 Marketing Operations

476 Marketing Research

478 Advertising Management

480 Marketing Strategy

481 Seminar on Change in Marketing

482 Seminar in Marketing and Management Sciences

483 Consumer Behavior

485 Service and Public Marketing

486 Demand Analysis for Marketing Planning

## Medical Care Organization and Administration

140 Introduction to Hospital and Medical Care Organization

141 Introduction to Clinical Medicine and Public Health

142 The Social Psychology of Hospitals

450 Evaluation of Community Health Services

451 Psychiatric Institutions: Administration and Practice

453 Legal Aspects of Hospital Administration

454 Policy and Planning for Health Care

455 Seminar in Health Research

457 Health Economics

459 The Political Economy of Medical Care Services

460 Quantitative Models in the Health Field

462 Seminar in Hospital and Health Services Administration

464 Field Studies in Health Administration and Research

465 Seminar in Comprehensive Health Planning

## Production and Operations Management

127 Operations Management

525 Problems and Techniques in Production Management

526 Case Studies in Production and Operations Management

## Public Administration

130 National Government: Institutions, Processes, Problems

131 Operations of the Intergovernmental System

132 The Administrative Process: Problems of Administration in a Democracy

**428 The Public Economy**

**554 Seminar in Urban Government and Administration**

**555 Towards the Resolution of Public Issues**

**557 Seminar in Political Economy and Public Policy**

**562 Comparative Local Government (Government 544)**

**750, 751 Integrative Seminar: Education for Public Management Program**

## Transportation Economics and Policy

**575 Transportation: Rates and Regulations**

**576 Transportation: Structures, Operations, and Policies**

## Research

**010 Directed Reading and Research**

**908 Research Seminar for Doctoral Candidates**

# Chemical Engineering

**5105 Advanced Chemical Engineering Thermodynamics**
Application of the general thermodynamic method to advanced problems in chemical engineering.

**5106 Reaction Kinetics and Reactor Design**
A study of chemical reaction kinetics and principles of reactor design for chemical processes.

**5107 Reactor Design**
Effects of heat transfer, diffusion, and nonideal flow on reactor performance. Optimum design for complex reactions.

**5109 Advanced Chemical Kinetics**
Reaction rate theory and application to complex reaction mechanisms; adsorption phenomena and application to heterogeneous catalytic reactions.

**5161 Phase Equilibria**
A detailed study of the pressure-temperature-composition relations in binary and multicomponent heterogeneous systems where several phases are of variable composition.

**5312 New Separation Techniques**
Discussion of new or less common separation techniques such as chromatography; ion exchange, electrophoresis, and membrane operations; analysis, design, and scale-up.

**5501 Methods of Chemical Engineering Analysis**
Methods of mathematical analysis of direct application in thermodynamics, transport phenomena, and reactor design.

**5505-5506 Advanced Transport Phenomena**
An integrated treatment of momentum, mass and heat transfer.

**5508 Diffusion in Membranes and Porous Solids**
Theories for diffusion of gases and liquids in porous solids and porous and dense membranes.

**5510, 5512 Numerical Methods in Chemical Engineering I and II**
Application of computer methods to the solution of complex chemical engineering problems.

**5605, 5606, 5607, 5608 Design Projects**
Individual projects involving the design of chemical processes and plants.

**5609 Mixing and Mechanical Separations**
Theory and application of mixing and mechanical separations involving fluids and solids.

**5621 Process Design and Economics**
Selection, design, and cost of process equipment. Market research and survey. Reactor arrangement and design.

**5622 Process and Plant Design**
Process design, including reactors, and separating system, and related process equipment. Plant layout and location. Cost estimates and project evaluation.

**5635 Marketing of Chemical Products**
Examination of marketing activities, organizations, and costs in the distribution of chemicals. A market research project is required.

**5636 Economics of the Chemical Enterprise**
Research economics; feasibility studies; information services; venture analysis; depreciation; planning.

**5642 Development Economics**
Planning, evaluation, and management of development activities in the process industries as related to research, processing, new products, markets, and long-range growth.

**5717 Process Control**
Dynamic response of processes and control instruments. Use of frequency response analysis, Laplace transforms, and electronic analogs to predict the behavior of feedback control systems.

**5731 Industrial Waste Management (Agricultural Engineering 506)**

**5741 Petroleum Refining**
A critical analysis of the processes employed in petroleum refining.

**5742 Polymeric Materials**
Chemistry of polymerization reactions, manufacture and properties of synthetic resins, fibers, plastics, and rubbers.

**5743 Properties of Polymeric Materials**
Mechanical, electrical, and optical properties of polymers. Phenomenological aspects and molecular theories of non-Newtonian flow, viscoelasticity, and ultimate tensile properties.

**5746 Case Studies in the Commercial Development of Chemical Products**
Detailed analysis of specific cases involving development of new chemical products. Emphasis on planning activities, research justification, and market forecasting. Profitability calculations and projections are required.

**5748 Fermentation Engineering**
An advanced discussion of fermentation as a unit process. Topics include sterilization, aeration, agitation continuous fermentation.

**5749 Industrial Microorganisms**
A brief introductory course in microbiology for students with a good background in chemistry.

**5752 Polymeric Materials Laboratory**
Experiments in the formation, characterization, fabrication, and testing of polymers.

**5760 Nuclear and Reactor Engineering**
Fuel processing and isotope separation, radioactive waste disposal, fuel cycles, radiation damage, biological effects and hazards, shielding, radiation chemistry.

**5761 Topics in Bioengineering**
Analysis of transport phenomena, reaction kinetics, process dynamics and control, and optimization in biological systems.

**5770 Engineering Analysis of Physiological Systems**
Engineering analysis and mathematical description of flow, transport phenomena, and chemical reactions involved in physiological system functions.

**5790 Consumer Products Engineering**
Engineering functions in the development of new consumer products. Interrelationship of research, marketing, and manufacturing.

**5851 Chemical Microscopy**

**5857 Electron Microscopy**

**5859 Advanced Chemical Microscopy**
Laboratory practice in special methods and special applications of chemical microscopy.

**5900 Seminar**
General chemical engineering seminar required of students majoring in the Field.

**5903 Seminar in Biochemical Engineering**

# Chemistry

**405 Techniques of Modern Synthetic Chemistry**
The syntheses of complex organic and inorganic molecules will be carried out with emphasis on the following techniques: vacuum line, high pressure, high temperature solid state, inert atmosphere, nonaqueous solvents, radioactive labeling, and photochemical and electrochemical methods.

**457 Advanced Organic-Analytical Laboratory**

**465 Advanced Organic Chemistry**
A survey of the simplest organic reactions within the framework of a mechanistic approach. The principal aim is to provide the skills and background needed to predict the reactivity patterns and stereochemical preferences of new molecules in a variety of experimental environments. Qualitative applications of statistical thermodynamics and molecular orbital theory will be illustrated by readings from the current research literature.

**466 Synthetic Organic Chemistry**
Modern techniques of syntheses; applications of organic reaction mechanisms to the problems encountered in rational multistep syntheses, with particular emphasis on newer developments.

**468 Chemical Aspects of Biological Processes**
Biochemical systems, bioenergetics, metabolic pathways. This course forms the basis of the chemical aspects of the graduate program in molecular biology.

**470 Chemical Ecology (Ecology and Evolutionary Biology 466)**

**481 Physical Chemistry III**
A discussion of advanced topics in physical chemistry, including an introduction to the principles of quantum theory and statistical mechanics, atomic and molecular spectra, and elementary valence theory.

**505-506 Advanced Inorganic Chemistry**
First term: introduction to group theory and its application to hybrid orbitals, molecular orbitals, and molecular vibrations of small molecules. Recent advances in the structure, bonding, and chemical properties of selected nontransition elements. Second term: crystal field theory, ligand field theory, magnetic and optical properties, thermodynamic cycles of aqueous ions, systematics of transition-metal chemistry.

**515-516 Selected Topics in Advanced Inorganic Chemistry**
Topics vary from year to year.

**525 Advanced Analytical Chemistry I**
The application of molecular spectroscopy to chemical problems. Topics discussed include ultraviolet, infrared, NMR, Raman, and mass spectroscopy.

**527 Advanced Analytical Chemistry II**
Modern analytical methods, including electron, Mössbauer and Fourier spectroscopy; mass spectrometry; methods applicable to macromolecules, and applications of on-line computers.

**528 Advanced Analytical Chemistry III**
Modern analytical methods, including atomic spectroscopy, solids mass spectrometry, x-ray and nuclear methods, separation techniques, and applications of on-line computers.

**565 Physical Organic Chemistry I**
Continues and extends the approach of 465 to more complicated organic reactions. Particular emphasis will be placed on the applications of reaction kinetics and isotope effects to an understanding of reaction mechanisms.

**566 Physical Organic Chemistry II**
Quantitative aspects of organic chemistry.

**570 Selected Topics in Organic Chemistry**
Topics vary from year to year.

**572 Mechanism of Enzyme Catalysis**
Enzymes, coenzymes, and model systems. Discussion of new physical methods for the study of enzyme processes.

**574 Chemistry of Natural Products**
Particular attention will be devoted to methods of structure determination and synthesis as applied to selected terpenes, steroids, alkaloids, and antibiotics.

**577 Chemistry of Nucleic Acids**
Properties, synthesis, and reactions of nucleic acids.

**578 Thermodynamics**
Development of the general equations of thermodynamics from the first and second laws. Applications to the study of physicochemical equilibria in gases, liquids, solids, and liquid solutions. Problems.

**580 Principles of Chemical Kinetics**
Principles and theories of chemical kinetics; special topics including fast reactions in liquids, enzymatic reactions, shock tubes, and molecular beams.

**582 Special Topics in Biophysical and Bioorganic Chemistry**
Topics vary from year to year.

**586 Physical Chemistry of Proteins**
Chemical constitution, molecular weight, and structural basis of proteins; thermodynamic, hydrodynamic, optical, and electrical properties; protein and enzyme reactions; statistical mechanics of helix-coil transition in biopolymers; conformation of biopolymers.

**589 X-Ray Crystallography**
Space groups, reciprocal lattices, three-dimensional diffraction, interpretation of x-ray diffraction data, structure determination by Fourier synthesis.

**593 Quantum Mechanics I**
Schrödinger's equation, wave packets, uncertainty principles, WKB theory. Matrix mechanics, orbital and spin angular momentum, exclusion principle, perturba-

tion theory, variational principle, Born-Oppenheimer approximation. At the level of Bohm, *Quantum Theory.*

**594 Quantum Mechanics II**
Time-dependent phenomena in quantum mechanics and interaction with radiation. Group theory and applications. Topics in molecular quantum mechanics. At the level of Tinkham, *Group Theory and Quantum Mechanics.*

**596 Statistical Mechanics**
Ensembles and partition functions. Thermodynamic properties of ideal gases and crystals. Third law of thermodynamics, equilibrium constants, vapor pressures, imperfect gases, and virial coefficients. Distribution and correlation functions. Lattice statistics and phase transitions. Bose-Einstein and Fermi-Dirac ideal gases. Maxwell theory of viscosity and heat conduction. At the level of Hill, *Statistical Thermodynamics.*

**598 Selected Topics in Physical Chemistry**
Topics are varied from year to year.

**600 General Chemistry Seminar**
A series of talks representative of all fields of current research interest in chemistry, other than organic chemistry, given by research associates, faculty members, and distinguished visitors. Normally attended by all students other than organic majors.

**601-602 Introductory Graduate Seminar in Analytical, Inorganic, and Physical Chemistry**
Weekly seminars on contemporary topics prepared and presented by first-year graduate students. Attention given to details of selecting, preparing, and presenting a given topic. Group preparation and participation emphasized. Required of all first-year graduate students majoring in chemistry and molecular biology.

**650-651 Graduate Seminar in Organic Chemistry**
A series of talks representative of all fields of current research interest in organic chemistry, given by research associates, faculty members, and distinguished visitors. Normally attended by all organic majors.

**700 Baker Lectures**

## Chinese Literature

**213-214 Introduction to Classical Chinese**

**314 Chinese Philosophical Texts**

**316 T'ang and Sung Poetry**

**402 History of the Chinese Language**

**403 Linguistic Structure of Chinese**

**411-412 Advanced Readings in Modern Chinese**

**413 Classical Chinese Prose**

**416 Pre-T'ang Poetry**

**418 Chinese Poetic Drama**

**420 Traditional Fiction**

**421-422 Directed Study**

**423 Readings in Shorter Works of Fiction**

**424 Readings in Literary Criticism**

**430 Readings in Folk Literature**

**503 Seminar in Chinese Poetry and Poetics**

**505 Seminar in Chinese Fiction**

**507 Seminar in Chinese Folk Literature**

**521-522 Advanced Directed Reading**

## City and Regional Planning

**512 Introduction to Urban and Regional Theory**
Survey of basic social science theories concerning man's occupancy of the earth; urbanization, intraregional distribution of population and activities, location of cities, demographic and functional structure of areas, intraurban distribution of population and activity.

**513 Introduction to Human Ecology**
An examination of the form and development of the human community with respect to spatial, temporal, and functional patterns of organization. Demographic, environmental, and technological characteristics are treated as parameters relevant to the ecological structure of the community.

**531 Planning Analysis**
City planning applications of general analytical techniques of social science; population, economic, land-use, and transportation models.

**536 Introduction to Computers in Planning**
An introduction to the use of computers in the problem-solving and planning processes. Students will run programs on the Cornell computer using FORTRAN or other appropriate programming language. Brief introduction to computer systems and the use of library routines. Advantages and limitations of using computers will also be considered.

**622 Techniques of Planning Implementation and Control**
Examination of one subset of new development in methods for analyzing and coordinating complex projects composed of many interrelated activities. Particular attention will be given to a discussion of the two most well-known versions of the network-based management-control systems, viz., CPM and PERT. Special attention will be focused upon the use of digital computer simulation as a potentially powerful extension of these systems.

**630 Planning Public Investments**
Examination of theory and practice of selected methods and techniques of analysis used in the planning and evaluation of public investments. Primary focus is upon the discussion of benefit, cost analysis, cost-effectiveness analysis, and capital budgeting, and the integration of these methods in planning-programming-budgeting systems. Emphasis given to the theoretical underpinnings of the methods, concepts of time and risk discounting, the social rate of discount, opportunity cost of public investment, social costs and externalities, distributional effects, treatment of uncertainty, timing of projects, alternative costs, valuation of idle resources, and use of shadow prices. In addition to a description of a PPBS system, a comparison of the rational approach inherent in the use of these methods will be compared with other approaches for making allocation choices, e.g., majority voting, partisan mutual adjustment systems, and disjointed incrementalism.

**631 Research Methods in Planning**
Basic coverage of some of the more common research techniques used in the social sciences, including a survey of basic data sources, methods of survey research, ecological methods, and some of the more fundamental statistical methods. A number of the methods covered will be utilized in developing a major research report in conjunction with requirements for the following year's field problem.

**632 Analyses for Planning Decisions I**
Will introduce some statistical and analytical methods and techniques that are applicable in the definition, analysis, and solution of various types of planning

problems. The nature of scientific inquiry and decision making and their relation to appropriate planning processes will be considered. Use of probability and statistics in drawing inferences from measurable experiences will be considered. Relevant topics in probability, sampling, estimation, hypothesis testing, and prediction will be examined.

**633 Analyses for Planning Decisions II**
Continuation of 632. Additional conceptual and applied techniques for rational decision making in the planning process will be considered. Topics to be introduced: decision making under uncertainty and value analysis, linear programming, network analysis, simulation, and cost/benefit analysis. Applications in the public sector will be examined as appropriate.

**637 Planning and Management Information Systems**
Methods and techniques for the design and use of computer-based planning and management information systems will be considered. The role of the computer and its effects on various planning, control, and decision functions will be introduced. Important hardware and software considerations in storing, processing, and retrieving of planning and management information will be covered, including data organization, on-line and batch processing, multiprogramming, file structures, telecommunications, etc. Applications in various public, medical, and business organizations will be examined. Students will be expected to program and run problems on the Cornell computer system.

**646 Workshop in Heuristic Gaming Techniques**
Exploration and use of a limited number of heuristic gaming devices dealing with problems in planning and urban theory and in public policy sciences. Students will be expected to develop at least a rudimentary model of their own design as part of the coursework.

**660 Introduction to Regional Development Planning**
Focus on problems of and theories about development of lagging, underdeveloped, or poor regions of both industrial and developing nations. Readings will survey various theoretical works upon which regional development planning is, or ought to be, based. Brief case studies will be used for illustration of difficult transition from theory to planning recommendations and policy implementation.

**663 Regional Planning and Development in Developing Countries**
Selected theories and development problems from 660 will be elaborated, deepened, and applied; extensive case studies of development planning will be analyzed and evaluated with those theories and with criteria suggested by them. The class will focus on the process of regional development through urbanization, and will look in particular at the concepts of equity and efficiency, external economies, export linkages, and internal self-sufficiency and integration. Resource development, national integration, human development, and migration problems will be discussed.

**671 Planning and Evaluation of Environmental Health Programs and Projects**
Major focus is an examination of the use of quantitative methods and economic analysis as aids to social decision making with regard to action in the area of environmental health. The purpose is to expose the student who already possesses a methodological competence to the application of these methods in the study of the particular problems of environmental health. Topics covered include: rational social decision making and environmental health; the economics of environmental quality management; investment models for the size and location of regional systems of waste treatment, water treatment, and solid-waste-disposal facilities; and selected mathematical and statistical models used to describe, explain, or identify selected environmental health problems.

**673 Economic Analysis and Human Resources Planning**
The purpose of this course is to examine economic analysis as it is currently being used in the areas of health planning, educational planning, selected areas of social planning, and urban renewal and housing, and to explore the potentiality for more extensive and powerful use in the future. The emphasis is upon application; students are assumed to have a foundation in basic economic theory, quantitative methods, and such techniques as PPBS, benefit cost analysis, and cost-effectiveness analysis.

**715 Seminar in Theory and Urban Structure**
Topics include interregional location theory and a review of various techniques of selecting optimum locations. The effects of new plants upon regional development are discussed as well as economic problems of declining open regions.

**716 Advanced Urban and Regional Theory**
Seminar in the theory of urban spatial organization. Economic, technological, and social factors leading to urbanization and various kinds of spatial organization will be explored. Major theoretical contributions to the understanding of intraregional and intraurban distribution of population and economic activity will be reviewed.

**717 Seminar in Urban and Regional Theory**
A continuation of 716 concentrating on recent developments.

**719 Informal Study in Urban and Regional Theory**

**732 Seminar in Regional Social Accounting**
An advanced seminar in methods of construction and regional application of social accounting. Topics covered include income and product accounts, balance of payments, money flows, and wealth accounting. Extensive references are made to methods used in various countries and to recent regional case studies.

**733 Seminar in Regional Interindustry Analysis and Programming**
Advanced treatment of regional industrial structure, methods of construction and applications of input-output, linear programming, integer and nonlinear programming, elements of game theory.

**736 Seminar in Urban and Regional Information Systems**
An examination of problems, methods, and uses of computer-based information systems in urban and regional planning. Subjects to be covered will vary from year to year and may, for example, include topics in the definition, acquisition, and organization of information for large-scale data bases; economic considerations in the use of information systems; analysis of applications in transportation, housing, health, and land-use studies; urban simulation models; applications of computer graphics in planning, etc. Students will be expected to undertake a significant term project.

**739 Informal Study in Planning Analysis**

**753 The Economics of Intrametropolitan Land Use**
The spatial arrangement of urban functions, value as determinant of land use, measurement methods, urban structures and forms, public interest and controls, urban renewal and redevelopment, and social and economic costs and benefits. Location of residential and industrial areas and retail centers.

**760 Seminar in Regional Model Construction**
Elements of a model, calibrating and simulation. Treatment of capital accumulation, existing resources, stability, disembodied and embodied technical progress. Vintage models, problems of capital valuation and capacity. Labor and migrations, balanced and unbalanced growth. The Harrod-Domar model, the two gaps, shift analysis. Some two sector and multisector models.

**761 Econometric Methods in Regional Planning**
Dynamic elements in regional models, treatment of time, depreciation, replacement and gestation lags. Linear and nonlinear systems. Elements of regional growth, friction of space, factor mobility, externalities and allocation of resources, growth poles, industrial complex analysis. Methods of estimating regional models, identification, recursiveness, indirect methods. Some recent regional models.

**790 Planning Research Seminar**
Presentation and discussion of current departmental research.

**799 Dissertation in City or Regional Planning**
Advanced independent research by candidates for the Ph.D. degree.

# Civil and Environmental Engineering

**2001 Thesis**
The thesis gives the student an opportunity to work out a special problem or to make an engineering investigation, to record the results of his work, and to obtain academic credit for such work. Registration must be approved by the professor in charge.

**2002 Civil and Environmental Engineering Practice**
Analysis of large engineering works; planning and organizing engineering and construction projects; professional practice; feasibility evaluations; financial justification of projects; social and political implications. The case method will be used extensively.

**2010-2011 Civil and Environmental Engineering Design Project I and II**
Design of a major civil engineering project embodying several aspects of civil engineering. Planning and part of preliminary design to be accomplished in the fall term. Remainder of preliminary design and final design in the spring term. Projects to be carried out by students working under the direction of a faculty project coordinator.

**2309 Hydrology**
Introduction to hydrology as a description of the hydrologic cycle and the role of water in the natural environment. Topics include precipitation, infiltration, evaporation, ground water, surface runoff, floods, and droughts.

**2312 Experimental and Numerical Methods in Fluid Mechanics**
Emphasis is on planning and conducting laboratory and field experiments and on numerical computation.

**2315 Advanced Fluid Mechanics I**
Introduction to vector and tensor notation. The equations of conservation of mass, momentum, and energy. Similitude and modeling potential flow including circulation, vorticity, conformal mapping, and hodograph methods.

**2316 Advanced Fluid Mechanics II**
Exact solutions to the Navier-Stokes equations, the laminar and turbulent boundary layers, turbulence, introduction to non-Newtonian flow, and other topics.

**2317 Free-Surface Flow**
The formulation of the free-surface equations and boundary conditions. Shallow water theory and the theory of characteristics. Unsteady and two-dimensional flow in open channels.

**2318 Dynamic Oceanography**
The statics and dynamics of oceans and lakes. Currents in homogeneous and stratified bodies of water. Tides, seiches, waves, and tsunamis. Turbulence and diffusion.

**2320 Analytical Hydrology**
Physical and statistical analysis related to hydrologic processes. Hydrometeorology and evaporation. Infiltration and base flow. Surface runoff and channel routing. Linear and nonlinear hydrologic systems analysis. Storage routing and unit hydrograph theory.

**2321 Flow in Porous Media**
Fluid mechanics of flow through porous solids. The general equations of single-phase and multiphase flow and the methods of solving the differential form of these equations. Hydraulics of wells, of infiltration and of groundwater recharge, and of other steady-state and transient seepage problems in fully and partially saturated materials.

**2391 Project**
The student may elect a design problem or undertake design and construction of special equipment in the fields of fluid mechanics, hydraulic engineering, or hydrology.

**2392 Research in Hydraulics**
The student may select an area for experimental or theoretical investigation in fluid mechanics, hydraulic engineering, or hydrology. Results should be submitted to the instructor in charge in the form of a research report.

**2393 Hydraulics Seminar**
Current topics in fluid mechanics, hydraulic engineering, and hydrology.

**2394 Special Topics in Hydraulics**
Special topics in fluid mechanics, hydraulic engineering, or hydrology.

**2406 Engineering of Foundations and Earth-Retaining Structures**
Mechanics and development of earth pressure in relation to soil properties and deformation. Design of retaining walls and bulkheads. Principles of bearing capacity, stress distribution, and settlement. Design of shallow and deep foundations, footing, raft, caisson, and pile foundations. Problems of construction and stability of excavations. Influence of groundwater flow on walls, foundations, and excavations.

**2410 Engineering Properties of Soils**
Natural environments in which soils are formed; the chemical and physical nature of soils. Principle of effective stress; shear strength and compressibility of natural geotechnical materials. Sensitivity, partial saturation, organic and frozen materials, anisotropy. Primary and secondary consolidation. Soil properties influencing permeability.

**2412 Graduate Soil Mechanics Laboratory**
The laboratory measurement of soil properties: classification tests; direct shear tests; triaxial tests for the measurement of pore water pressure; strength parameters. Pore pressure dissipation tests. Relationship of laboratory tests to field behavior.

**2414 Advanced Geotechnical Engineering**
A review in more detail of topics covered in 2406 with additional discussion of recent improvements. Topics include site investigations; theories of bearing capacity for shallow and deep foundations; earth pressure on retaining walls, braced excavations, sheet pile walls and tunnels; settlement and consolidation.

**2416 Slope Stability: Earth and Rockfill Dams**
Principles of stability for earth and rock slopes; effects of pore water pressure; short- and long-term stability; problems of draw-down; analysis of landslides and dam stability; principles of earth and rock fill dam design; internal pore water pressures and drainage; filters; relief wells; foundation problems; grouting; cutoffs; control and instrumentation.

**2418 Case Studies in Soil Mechanics and Foundation Engineering**
The study of real engineering problems of various types; the importance of the geological environment in recognizing the nature of field problems; application of mechanics and soil properties to obtain engineering solutions. Preparation of engineering reports.

**2431 Pavement Design and Construction**
Part I: subgrade evaluation; compaction; drainage and frost action; stabilization. Part II: aggregates; bituminous materials; evaluation of flexible pavement components; design and construction of flexible pavement structure. Part III: design and construction of rigid pavements.

**2432 Highway Engineering (Agricultural Engineering 491)**
Emphasis is on secondary roads in the study of economic considerations in road system improvement; road improvement planning and programming; road location and geometric design; engineering soil characteristics and classification; design of roadbed thickness; drainage; stabilization methods and materials; dust palliatives; wearing surfaces.

**2445 Field Practice in Geotechnical Engineering**
This course is designed to provide experience with field conditions in important project environments within reach of the campus, including construction scenes in New York and central Pennsylvania. Preparation for and reports on various sites are a requirement. Engineering construction practices and site evaluation related to landslides, bedrock, drainage, and unstable soils. The influence of rock types, groundwater, and soil materials on existing structures; appropriate design procedures at difficult sites.

**2462 Geophysical Geodesy**
Basic potential theory, Laplace and Poisson equations; gravity and potential field in, on, and outside the spheroid; figure of the earth, application of Stokes formula for determining undulations of the geoid and deflection of the vertical; applications of spherical harmonics.

**2464 Geodetic Measurements**
Study of instrument systems, and application thereof, for geodetic and related measurements with emphasis upon high-quality results. Topics include systems for leveling, angle measurement, electro-optical and other distance measurement systems, and astronomic determination of azimuth and geographical positions.

**2466 Map Projections and Cartography**
Theory of map projections including conformal, equal-area, azimuthal equidistant, etc., projections; coordinate transformations; plane coordinate systems for surveying. Design of map projections. Cartographic principles, systems, and related economic factors.

**2473 Analytical Aerotriangulation**
Analysis, theories, and computation of stereostrip triangulation by direction cosines, vector, and matrix methods. Coplanarity and colinearity equations for relative and absolute orientation. Stereogram assemblage and coordinate transformation of strip and block coordinates. Cantilever extension and general bridging solutions. Propagation of errors.

**2481 Identification, Classification and Measurements of Environmental Components**
Airphotos and other sensors used to identify surficial land uses and cultural features including both rural and urban scenes; fundamentals of agricultural soils and their conversion to planning uses; topographic, hydrologic, soil, geologic, climatic, and thematic maps; and an analysis of various land classification systems. Extension of principles and concepts of topographic and nontopographic photogrammetry.

**2482 Evaluation of Earth Resources I**
Evaluates the interplay between the physical environment and major types of engineering projects. Earth resources are explored and evaluated as they affect engineering and planning decisions. Methods include field reconnaissance, engineering data, subsurface records and interpretation of in-situ soils, soil maps, geologic maps, airphotos, and meterological data.

**2484 Analyses and Interpretation of Aerial Photographs**
Methods of identification of a broad spectrum of soils, rocks, and drainage conditions as well as the significance of vegetative patterns of the world. Specific fields of application are emphasized, such as in site evaluation for housing and industry.

**2485 Advanced Interpretation of Airphotos and Imagery Patterns**
A study of physical environment by use of airphotos and other remote sensing methods. Intensive practice using conventional photography. Projects using sequential photography, multiple spectral photography, space photography, infrared thermal and radar imageries.

**2486 Geophysical Measurements I**
Introduction to measurements of geophysical processes and their effect on environment, including: earthquake mechanisms; introductory seismology, with emphasis upon shallow seismic exploration of the earth's crust, geopotential fields—gravity, electrical, and magnetic—and measurement of field anomalies. Geometric measurements related to these processes; quantitative evaluation of measurements and use of evaluation methods for the design of systems and observing programs.

**2487 Evaluation of Earth Resources II**
Land use and resource inventory methods and resource reserves estimates; restoration and rehabilitation of the environment especially related to areas of engineering responsibilities. Special consideration is given to the unique qualities of the tropical, arctic, and arid regions. Extensive resource materials are available for case studies.

**2488 Geophysical Measurements II**
Extension of principles and concepts of photogrammetry to include: stereoplotters, computational photogrammetry, and the related effects of curvature of the earth. Geometrical geodesy and related topics.

**2491 General Design Project in Geotechnical Engineering**
Design problems frequently associated with the M.Eng. program.

**2492 Research in Geotechnical Engineering**
For students who wish to study one particular area of geotechnical engineering in depth. The work may be a laboratory investigation, field study, theoretical analysis, or the development of design procedures.

**2493 Seminar in Geotechnical Engineering**
Presentation and discussion of technical papers and current research in the general field of geotechnical engineering or one of its specialized fields.

**2494 Special Topics in Geotechnical Engineering**
Supervised study in small groups in one or more special theoretical or applied topics not covered in the regular courses.

**2495 Seminar in Geodetic and Photogrammetric Engineering**
Student presentation, discussion, and editing of technical papers and review of current research in geodesy, photogrammetry, cartography, and land surveying. Occasional guest speakers.

**2502 Water Quality Engineering**
Introduction to water quality engineering, including water supply, water and waste water treatment and disposal. Principles applicable to the behavior of municipal and industrial effluents in natural waters. Elements of analysis and design of municipal water supply systems and waste water and storm water collection and disposal systems.

**2510 Chemistry of Water and Waste Water**
Principles of physical, organic, inorganic, and biochemistry applicable to the understanding, design, and control of water and waste water treatment processes, and to reactions in receiving waters.

**2513 Biological Phenomena and Processes**
Theoretical and engineering aspects of biological phenomena and processes applicable to the removal of impurities from water, waste water, and industrial wastes, and to their stabilization in receiving waters. Pertinent microbiological principles, biological oxidation, kinetics, and eutrophication. Analysis and design of biological treatment processes. Laboratory studies of pertinent phenomena and processes.

**2514 Chemical and Physical Phenomena and Processes**
Theoretical and engineering aspects of chemical and physical phenomena and processes applicable to the removal of impurities from water, waste water, industrial wastes, and receiving waters including reaction kinetics, transfer and dispersion phenomena, and fine particle mechanics. Analysis and design of conventional and advanced treatment and disposal processes. Laboratory studies of pertinent phenomena and processes.

**2515 Water Resources Problems and Policies**
A comprehensive approach to water resources planning and development. Historical and contemporary perspectives of water resource problems, organization, and policies.

**2518 Water Resource Systems**
Application of economics, engineering, and systems theory to water, waste water and related resource planning and management. Development of deterministic and stochastic models. Review of current literature.

**2520 Environmental Quality Control**
Environmental quality and pollution problems. Environmental quality control concepts, objectives, and methods. Ecologic, economic, health, regulatory, and technologic considerations. Air and water quality criteria, standards, and control. Disposal of solid wastes and radioactive wastes.

**2530 Solid Waste Management**
Study of municipal, industrial, and agricultural solid waste. Emphasis on waste characteristics; methods of treatment and disposal; and interrelationships with the air, water, and land environment.

**2531 Industrial Waste Engineering (Agricultural Engineering 506, Chemical Engineering 5731)**
The first third of the course considers legal aspects, assimilatory capacity of receiving waters, joint industry-municipal collection of wastes, and sewerage service charges. The second third involves waste sampling and analysis, treatment processes, waste-reduction possibilities, water quality and quantity, reuse and recovery, and costs. The last third includes specific industrial operations and selected case studies of industrial waste treatment. An in-depth study of a particular waste problem is required.

**2533 Environmental Quality**
Introduction to environmental quality and pollution problems and their relationship to man. The ecologic, economic, regulatory, and technologic aspects of air quality control and water quality control. Waste treatment and disposal methods.

**2534 Air Quality Control**
Elements of air quality control. Sources, nature, and interactions of gaseous and particulate pollutants in the atmosphere. Air quality criteria, standards, legislation, control methods, and technology.

**2545 Water Resources Planning Seminar**
The concepts, processes, and techniques of regional, multipurpose river basin planning and development. Uses the case study method, with preparation of an integrated, comprehensive report for the study area.

**2547 Environmental Policy Analysis**
Current research topics in the application of economic optimization and simulation techniques for defining and evaluating public policy alternatives for managing air, land, and water resources and the material and energy wastes released into the environment. The influence of technologic, economic, and political uncertainty will be emphasized. Each student will select a particular environmental management problem and structure models or methods for analyzing alternative solutions.

**2591 Design Project**
The student will elect or be assigned problems in the design of water and waste water treatment processes or plants; waste water disposal systems; water quality control systems; water resource development or management systems; or laboratory apparatus of special interest.

**2592 Sanitary Engineering Research**
Study of a special topic or problem in greater depth than is possible in formal courses.

**2593 Environmental Protection and Management Colloquium or Seminar**
Discussion of current topics and problems in sanitary and water resources engineering. Required of graduate students majoring or minoring in either subject.

**2594 Special Topics in Sanitary and Water Resource Systems Engineering**
Supervised study in special topics not covered in formal courses.

**2605 The Law and Environmental Control**
An introduction to the structure and operation of the legal system and the manner in which it may handle environmental problems. The interaction of law and science; regional problems and political jurisdictional boundaries; the police power of the states; statutory law and case law; the judicial function; the nature and

functions of the administrative agencies; environmental regulation; recent environmental case law; the interstate compact.

**2606 Seminar in Technology Assessment**
An interdisciplinary seminar dealing with the social consequences of future technological development and the means by which technology can be guided in socially beneficial directions. Student/faculty task forces will undertake projects exploring aspects of technology assessment theory and methodology, perform simple assessments, or investigate questions pertaining to the design and functioning of institutions to perform such tasks.

**2611 Microeconomic Theory I**
Scope and method of economics. Individual and market demand. Cost curves. Supply curves. Competitive equilibrium. Dynamic adjustment and stability. Monopoly. Price discrimination. Economic efficiency. Applications of price theory to public policy: agricultural policy, tax policy, government regulation of public utilities. Operation of public enterprises.

**2612 Microeconomic Theory II**
The theory of imperfect competition. Oligopoly and game theory. Monopolistic and spatial competition. The theory of consumer behavior. Cardinal utility and ordinal utility theory. Revealed preference theory and index numbers. Consumer surplus. Intertemporal choice. Uncertainty.

**2613 Macroeconomic Theory**
National income accounting. Money and banking. Federal Reserve policy. Classicial model of employment. Inflation. Keynesian model of income determination. Theories of consumption and investment. Fiscal policy. Foreign trade. Dynamic macro-models: accellerator-multiplier interaction. Harod-Domar growth model. Neoclassical growth models. Population growth. Regional development models.

**2617, 2618 Public Systems Analysis I and II**
First term is an introduction to the use of systems analysis in structuring public decision problems. Second term is a survey of the applications of systems analysis techniques to public sector problems. Some of the areas to be considered are transportation systems, water resources, and environmental quality management.

**2619 Environmental Systems Analysis**
Application of systems analysis and economics to water resource and environmental quality management. Design and operation of water resource systems. Evaluation of public policy alternatives for air, land, and water resources and the material and energy wastes released into the environment. Development of deterministic and stochastic models for steady-state and dynamic conditions.

**2620 Transportation Engineering**
Transportation systems analysis; traffic generation, distribution, and assignment models; modal split models. Elements of traffic flow theory and congestion analysis. Terminals and transfer delays. Physical environment evaluation, including route location and use of aerial photography. Transport economics and current policy issues. Technological and economic characteristics of current transportation modes.

**2621 Urban Transportation Planning I**
The urban transportation problem: its roots, manifestations, and implications; the systems analysis approach to transportation; the demand-and-supply side of transportation; the urban transportation planning process; generation of alternatives and their evaluation; introduction to decision theory.

**2622 Multivariate Analysis Methods in Transportation**
A course in multivariate methods for statistical model-building in transportation and other urban systems, including linear and nonlinear regression analysis, weighted regression, canonical correlation, factor analysis, simultaneous equations methods, discriminant analysis, probit analysis and logit analysis; with applications to transportation demand modeling.

**2623 Urban Transportation Planning II**
Advanced study of conventional models of travel demand in transportation studies, including residential and nonresidential trip generation; Fratar, Gravity, and opportunity models of trip distribution; trip-end and trip-interchange modal split; network assignment. New methods of travel demand modeling, including spatial distribution theories, "abstract mode" models, individual behavior theories. The propagation of errors in models.

**2624 Transportation Systems Analysis**
Techniques of systems analysis applied to physical planning, operating, and financing of transportation facilities. Wherever applicable, mathematical models of transportation processes are used to examine questions related to the development of optimal public policy decisions in the area of transportation. Attention is given to analysis of single and multimodal forms of transportation. Mathematical programming, simulation, and stochastic processes are employed.

**2640 Traffic Flow Theory**
Study of various mathematical theories of traffic flow. Microscopic models (car-following models). Macroscopic models (kinematic wave theory). Stochastic properties of traffic flow at low density. Probability models for traffic lights and optimal control of signalized intersections. Traffic flow on transportation networks. Application to traffic assignment. Traffic networks simulation system.

**2641 Airport Planning and Operations**
Terminal access; location and site selection; terminal design and operations; metropolitan air transit systems; environmental impact of airport location; air traffic flow analysis; air traffic control; aircraft technology.

**2643 Design and Planning of Mass Transportation**
A study of mass transportation of the past and present; innovative forms of mass and individual transportation in urban areas. The financing and organization of mass transportation: the "free transit" vs. fares dilemma. Planning for mass transportation: special applications; implementation of plans; planning transportation in new towns.

**2644 Transportation Systems Evaluation**
Economic evaluation techniques; measures of effectiveness; cost-effectiveness evaluation; definition of goals, objectives, criteria for transportation planning, impact analysis and evaluation.

**2680 Environmental Control Workshop**
Students interested in research topics dealing with control of the environment, especially biological and ecological aspects, are encouraged to participate. Topics discussed in previous workshops include human population control, control of pest and parasite populations, study of species' strategic use of food supply, control of populations by use of predators, host-parasite systems. Additional topics will be developed.

**2691 Public Systems Analysis Design Project**
Design of feasibility study of public systems, supervised and assisted by one or more faculty advisers. Individual or group participation. Final report required.

**2692 Public Systems Analysis Research**
Investigation in depth of particular public systems problems.

**2693 Public Systems Planning and Analysis Colloquium**
Lectures on various topics.

**2694, 2695 Special Topics in Public Systems Planning and Analysis**
Supervised study by individuals or small groups in one or more specialized topics not covered in regular courses.

**2710 Strength of Structures**
Analysis of two- and three-dimensional stress and strain. Theories of failure of ductile and brittle materials. Microstructure of materials. Structural materials under load, strain hardening, Bauschinger effect, residual stresses, hysteresis, stress concentration, brittle fracture, creep, alternating stress. Design for fatigue. Stresses beyond the elastic limit. Inelastic behavior of steel and reinforced concrete structures. Critical discussion of recent research and current design specifications.

**2711 Buckling: Elastic and Inelastic**
Analysis of elastic and plastic stability. Determination of buckling loads and post-buckling behavior of columns. Solid and open-web columns with variable cross-section. Beam columns. Frame buckling. Torsional-flexural buckling. Lateral strength of unbraced beams. Buckling loads and post-buckling behavior of plates, shear webs, and cylindrical shells. Critical discussion of current design specifications.

**2712 Advanced Structural Analysis**
Stability, determinacy, redundancy of structures. Approximate methods of analysis. Force, displacement, and transfer matrix methods of matrix structural analysis. Development of space frame element equations, including distributed loads and thermal strain effects. Methods of solution: direct and iterative, tridiagonalization, partitioning, and special transformations. Analysis techniques for tall buildings and other special problems.

**2713 Finite Element Analysis**
Theoretical and conceptual bases for formulation of finite element representations in continuum mechanics. Development of element relationships for structural analysis of plates, shells, and solids. Extension of element and system solution techniques to deal with problems in elastic stability, inelastic deformation, finite displacements, dynamic response, and other special behavior mechanisms.

**2714 Structural Model Analysis and Experimental Methods**
Dimensional analysis and principles of similitude. Direct model analysis, including materials, fabrication, loading, and instrumentation techniques. Basic techniques of experimental stress analysis. Confidence levels for model results. Laboratory projects in elastic behavior and ultimate strength of model structures.

**2715 Probabilistic Concepts in Structural Engineering**
Introduction to probability concepts pertaining to engineering design and reliability, probabilistic models, inference techniques; decision analysis, stochastic processes, applications in structural safety decisions, and structural random vibration.

**2716 Concrete Structures I**
Analysis, design, and behavior of prestressed concrete structures; beams, slabs, composite construction, continuous beams and frames, tension and compression members; deflection analysis, end zone stresses, detailing losses, efficiency. Design of concrete shells, shells of revolution, hyperbolic paraboloids.

**2717 Concrete Structures II**
Analysis, design, and behavior of reinforced concrete structures; safety considerations, deflection analysis, crack control; beams, columns, slabs, continuous frames, flat plates, flat slabs, composite construction; limit analysis and yield line theory; design of concrete shells; folded plates and cylindrical shells.

**2718-2719 Behavior and Design of Metal Structures**
Contemporary methods for analyzing and designing metal structures. Behavior of structural elements and frames. Selected design applications from the fields of steel plate structures, bridges, suspension systems, light-weight structures.

**2720 Shell Theory and Design**
Differential geometry of surfaces. Bending and membrane theory of shells. Analysis and design of cylindrical shells, domes, paraboloids. Application to reinforced concrete roofs and pressure vessels. Stability of certain types of shells.

**2722 Structural Design for Dynamic Loads**
Equations of motion and vibration of simple systems. Numerical, energy, and matrix methods of analysis of multiple-degree systems. Analysis and design of structures for ground disturbances, including inelastic effects.

**2730, 2731 Transportation Structures (Theoretical and Applied Mechanics 1730, 1731)**
Treatment of structural design aspects of land, sea, and air vehicles. Description of applicable design specifications, design environments, materials failure criteria, forms of construction, and methods of structural analysis. Term paper required.

**2732 Optimum Structural Design**
Classification of optimum structural design problems; merit functions and design variables. Fully stressed design. Mathematical programming methods in optimum structural design, including linear programming, gradient projection, and penalty function procedure. Classical methods, including Lagrangian multipliers and variational concepts. Application to truss and beam design situations is emphasized.

**2751 Engineering Materials**
Engineering properties of concrete, steel, wood, and other selected structural materials; physico-chemical properties of soils, concrete, and bituminous materials. Design characteristics and significance of test results of materials used in engineering works. Extensive laboratory testing and report writing.

**2752 Advanced Plain Concrete**
Topics in the field of concrete, such as history of cementing materials, air-entrainment, lightweight aggregates, petrography, durability, chemical reactions, and properties of aggregates. Relationships between internal structure, physical properties, chemical properties, and mechanical properties of interest to the design and construction engineer.

**2753 Structure and Properties of Materials**
Internal structure of materials ranging from the amorphous to the crystalline state. Forces holding matter together versus forces causing deformation and failure. Correlation of the internal structures of materials with their physical and mechanical properties. Applications to various engineering materials.

**2757 Civil and Environmental Engineering Materials Project**
Individual projects involving civil engineering materials.

**2758 Civil and Environmental Engineering Materials Research**
Individual assignments, investigations, and/or experiments.

**2790 Planning of Structural Systems**
Functional, structural, and other considerations in the planning and selection of structural systems. Probabilistic description of loading and strength. Preliminary design—estimating overall dimensions, weights, proportioning of members, joints—optimization. Preliminary analysis of frames, trusses, plates, and shells. Erection, construction, and stress control considerations. Computer structural analysis. Case studies with the participation of practicing engineers.

**2791 Design Project in Structural Engineering**
Comprehensive design projects by design teams. Formulation of alternate design proposals, including economics and planning, for a given situation and complete design of the best alternate. Determination of construction costs and preparation of sketches and drawings. Presentation of designs by oral and written reports.

**2792 Research in Structural Engineering**
May be an investigation of existing types of construction, theoretical work aimed at simplifying present methods of design or proposing new methods, or experimental investigation of suitable problems.

**2793 Structural Engineering Seminar**
Preparation and presentation of topics of current interest in the field of structures for informal discussion.

**2794 Special Topics in Structural Engineering**
Individually supervised study in one or more topics, such as tanks and bins, suspension bridges, towers or movable bridges, which are not covered in the regular courses. Independent design or research projects may also be selected.

# The Classics

## Greek

**111 Modern Greek**

**301 Greek Historians**

**302 Greek Tragedy**

**305 Aristophanes and Attic Prose**

**306 Greek Melic, Elegiac, and Bucolic Poetry**

**407 Graduate Reading Course**
A reading course in a major author or genre. Subject to be determined.

**408 Greek Epic: Homer and Hesiod**

**442 Greek Philosophy**

**501-502 Independent Study for Graduate Students**

## Latin

**315 Roman Satire: Horace and Juvenal**

**316 Roman Epic: Virgil and Lucan**

**317 Roman Historiography: Livy, Tacitus, Sallust**

**318 Augustan Poetry**

**367 Medieval Latin Literature**

**415 Silver Age Literature**

**416 The Works of Horace**

**551-552 Independent Study for Graduate Students**

## Greek and Latin Composition

**Greek 409-410 Advanced Greek Composition**

**Latin 431-432 Latin Composition: Advanced Course**

## Classical Linguistics

**421-422 Historical Grammar of Greek and Latin**

**423 Vulgar Latin**
An introduction, via selected late Latin texts, to the popular Latin from which the Romance languages are derived.

**424 Italic Dialects**
Selected texts in Oscan and Umbrian will be studied both for their own interest and for their bearing on historical Latin and Indo-European linguistics.

**425 Greek Dialects**

**426 Old Latin**

## Archaeology

**220 Introduction to Classical Archaeology**

**319 Pre-Classical Greece**
Aegean archaeology from the Neolithic period to the eighth century B.C.

**320 Archaeology of Classical Greece**
Study of select monuments of ancient Greece from the eighth century to the Hellenistic period.

**322 Arts of the Roman Empire**
The visual arts in the service of the first world state. The course starts with the Etruscan and Republican periods and ends with the conflict of styles in the Early Christian Period.

**431 Greek Sculpture (History of Art 431)**

See also History of Art and Archaeology 313, 314, 521, 523.

## History

**571 The Hellenistic Epigram**

**572 Pindar**

**579 Seneca**

**580 Seminar**

See also History 431–432, 631–632 and 635–636.

# Communication Arts

**200 Theory of Human Communication**

**214 History of Mass Communication**

**215 Introduction to Mass Media**

**301 Oral Communication**

**302 Advanced Oral Communication**

**303 Small Group Communication**

**311 Radio and Television Communication**

**312 Advertising and Promotion**

**313 Writing for Magazines**

**315 News Writing and Analysis**

**316 Science Writing**

**318 Radio Writing and Production**

**319 Television Writing and Production**

**401 Communication Law**

**403 Topics in Communication Theory**

**404 Psychology of Communication**

**430 Visual Communication**

**431 Art of Publication**

**501 International Communication**
Analysis of the purposes, techniques, and effects of organizations involved in cross-national communication, with particular emphasis on the mass media and the flow of information between nations. Also considered are the international conventions and other agreements that pertain to international communication.

**512 Seminar: Interpersonal Communication**
A study of recent advances and research in listening, conference, small-group interaction, and nonverbal communication. New developments will be examined as they relate to business, administration, and education.

**521 Seminar: United States Communication**
An examination of the structure of communication in the United States focusing particularly on the organization, content, controls, and audience of the print, broadcast, and film media. Selected media of other nations are included in the analysis to provide a perspective on the U.S. system.

**524 Communication in Developing Nations**
An examination of existing communication patterns and systems and their contributions to the development process. Special attention is given to the interaction between communication development and national development in primarily agrarian societies.

**526 Comparative Mass Media**
A study of the mass media in several national settings with particular attention to the structure, controls, audience, and content of press and telecommunications.

**531 Studies in Communication**
A review of classical and contemporary research in communications, key concepts, and areas of investigation. Exploration of the scope of the field and the interrelationships of its various branches.

**532 Methods of Communication Research**
An analysis of the methods employed in communications research. Particular concern is given to the philosophical rationale behind experimental, descriptive, and historical-critical research methods.

**543 Frontiers in Communications**
A study of current developments in communication, with an emphasis on the creative application of the newest methods, materials, and technology in visual, print, film, oral, and telecommunication media to contemporary and future problems in communication. Examples include the applications and implications of satellite communication, multimedia "self-teaching" systems, mobile printing technology, facsimile, electronic video recorder, laser beams, etc.

**550 Advanced Communication Seminar**
An opportunity to study and work on special problems in communication.

**595 Directed Graduate Study**

# Comparative Literature

**400 Greek and Roman Drama**
A study by lecture and discussion of the evolution of forms and themes in ancient tragedy and comedy, as exemplified by representative plays, read in translation, of Aeschylus, Sophocles, Euripides, Aristophanes, Menander, Plautus, Terence, and Seneca. Consideration is given also to the origins of tragedy and comedy, and to the ancient theatre. The main emphasis is on tragedy, with some attention to the influence of Greek tragedy and Seneca on later European tragedy.

**402 Allegory and Symbolism**
Definitions and models drawn from the *Divine Comedy* will be related to a reading of works ranging from classical to modern, such as Prudentius' *Psychomachia,* the *Romance of the Rose,* mystical lyrics of St. John of the Cross and others, and the *Faerie Queene, Faust Part II,* and selected works of Kafka.

**404 Medieval Arthurian Literature**
A survey of Arthurian literature from the twelfth to the fifteenth century. Special attention will be given to the relations of the English and French Arthurian traditions. Reading will include selections from the *Mabinogion,* the Didot *Perceval,* the Middle English alliterative *Morte Arthure, Sir Gawain and the Green Knight,* and works of Marie de France, Chrétien de Troyes, Chaucer, and Sir Thomas Malory.

**405 The Enlightenment in Germany, France, and England**

**408 Ancient and Renaissance Literary Criticism**
A study of ancient and Renaissance poetic and rhetorical theory, with special reference to Plato, Aristotle, Horace, Quintilian, and Longinus, and to Scaliger and Castelvetro as Renaissance interpreters of the classical formulations.

**413 Modern Italian Literature**
A thematic study of such authors as Verga, Svevo, Pirandello, Tomasi di Lampedusa, Basani, Pavese, and Moravia. Readings, lectures, and discussion in English.

**416 Myth and Literature**
Readings in mythography, literature, and criticism of the nineteenth and twentieth centuries. Emphasis will be on Yeats and Stevens.

**421 Nature and Norms in Renaissance and Baroque Literature**

**424 Italy and the Transalpine Renaissance**

**440 Autobiography as a Literary Form**

**442 Modern Dramatists**
Topics to be announced. All readings in English translation.

**450 The History of the Book**
Morphology of letters (calligraphy and type). Abbreviations and their cultural significance. Printing and its terminology. The book as a physical object. The impact of the book on social and economic changes. The book as a work of art.

**455-456 Independent Study**

**462 Eighteenth-Century Comedy**
Theory and practice in England, France, and Germany.

**467 From Narcissus to Dionysus**
Three variations on the theme of Narcissus in Pavese, Hawthorne, and Nerval.

**469 Dostoevsky, Mann, and Gide**
The development of the novel form and of certain important themes, as illustrated in some of the chief works of these three representative authors. *Notes from Underground, The Brothers Karamazov, The Magic Mountain, Death in Venice,* and *The Counterfeiters* will be discussed.

**470 Three Novelists: Stendhal, Dickens, and Mann**
The realistic tradition in European fiction to 1910. A discussion of six or seven major European novels, including types of the historical novel, the family chronicle, and the *Bildungsroman.* Readings will include *The Charterhouse of Parma, Bleak House, Great Expectations, Buddenbrooks,* and Mann's major novellas.

**472 Origins of the Avant-Garde**
An introduction to the early avant-garde period. Discussion of such general topics as the changed attitude towards language, the role of an avant-garde criticism, the synthesis of the arts. Study of representative works by European artists and writers. Some special attention will be given to the role of Russian artists in the avant-garde movement. The course will be run as an expanded seminar, and the range of topics will be adjusted to suit class interests.

**501-502 Topics in Modern Literature**

**512 Poetic Traditions of the Renaissance**
Focuses on the Renaissance attempt to forge new verse forms appropriate to traditional genres—epic, lyric, and dramatic. Emphasis will be on Ariosto, Ronsard, and Shakespeare.

**514 Modern Parody**
A study of the forms and functions of parody in modern literature exemplified by T. S. Eliot (*The Waste Land, The Cocktail Party*), Beckett (*Fin de Partie et al.*), Ionesco (*La Cantatrice Chauve*), Borges (*Labyrinths, the Aleph),* Nabokov *(Lolita* or *Pale Fire),* and Barth *(Lost in the Funhouse*). The theoretical framework for these works will be developed on the basis of the literary theories of the Russian formalists, Eliot, Frye, and Bakhtin. Reading knowledge of French is required.

**516 Poe, Baudelaire, and Modernist Poetics**
Structural and hermeneutic approaches to poetry.

**639-640 Special Topics in Medieval Studies**

# Computer Science

**385 Introduction to Automata Theory**
Models of abstract computing devices. Finite automata and regular expressions and sets. Input-output experiments, nondeterministic machines, parallel and sequential realizations, and algebraic structure theory. Pushdown automata and context-free languages. Closure properties and decision problems. Turing machines and recursively enumerable sets. Universal Turing machines, the halting problem, decidability.

**401 Introduction to Computer Systems and Organization**
Characteristics and structure of digital computers as hardware units. Representation of data, addressing of data, index registers, indirect and base-plus-displacement addressing. Codes for error detection and corrections. Introduction to computer microstructure, gates, flip-flops, adders, storage and peripheral hardware and their characteristics, the input-output channel, interrupts. Assembly language programming: format and basic instructions, the assembly process, loops and indexing, data types, subroutines, macros. Brief description of operating systems, loaders, interpreters, and compilers. Programming and debugging assembly language programs on a computer are an essential part of this course.

**404 Advanced Computer Programming**
For students who wish to learn computer programming for eventual use in professional systems programming or advanced applications. The basic logical and physical structure of digital computers is considered and the applicability and limitations of the structure are studied through many examples and exercises. The approach, therefore, is not a theoretical one, but rather an engineering one, emphasizing techniques. Students participate in a large systems-programming design and implementation effort.

**409 Data Structures**
Data structures, relations between data elements, and operations upon data structures. Bits, bytes, fields, arrays, stacks, trees, graphs, lists, strings, records, files and other forms of data structures. Primitive operations, accessing techniques, and storage management techniques appropriate to each class of data structures. Sorting and searching techniques, symbol table structures. Data structures in programming languages, retrieval systems, and data management systems. Formal specification of classes of information structures.

**411 Programming Languages**
An introduction to the structure of programming languages. Specification of syntax and semantics. Properties of algorithmic, list processing, string manipulation, and simulation languages: basic data types and structures, operations on data, statement types, and program structure. Macro languages and their implementation. Run-time representation of programs and data. Storage management techniques. Introduction to compiler construction.

**412 Translator Writing**
Models and techniques used in the design and implementation of assemblers, interpreters, and compilers. Topics include: lexical analysis in translators, compilation of arithmetic expressions and simple statements, specification of syntax, algorithms for syntactic analysis, code generation and optimization techniques, bootstrapping methods, compiler-compiler systems.

**413 Systems Programming and Operating Systems**
The organization and software components of modern operating systems. Batch processing systems: loaders, input-output methods. Cooperating sequential processes: parallel programming, synchronization techniques. Introduction to multiprogrammed systems: the "process" model, virtual machines. Storage management: relocation, protection, allocation. Procedure and data sharing. Process scheduling and control. General resource management. File systems: logical and physical organization, protection. Case studies. Additional topics such as systems simulation, job control languages, and microprogramming. Projects involving design and implementation of systems modules.

**415 Machine Organization**
Design and functional organization of digital computers. Boolean algebra, elements of logical design and computer components. Counters, shift registers, half and full adders, design of arithmetic units. Memory components, accessing and retrieval techniques, addressing structures, realization of indexing and indirect addressing. Control unit structure, instruction decoding, synchronous and asynchronous control. Input-output channels, buffering, auxiliary memory structure, interrupt structures. Overall systems organization, reliability, system diagnostics, system simulation.

**416 Operations Research Models for Computer and Programming Systems**
Modeling and analysis of computer hardware and software systems. Some applications of the theories and techniques of operations research to problems arising in computer systems design and programming. Operating systems design: resource allocation and scheduling. Queuing models for time-sharing and multiprogramming

systems. Reliability of computer systems and computer networks. Statistical techniques for measuring systems performance. Simulation of hardware and software; systems balancing. Applications of stochastic processes and inventory theory, e.g., file organization and management, models of computer center operation. Mathematical programming techniques applied to hardware configuration selection. Students will program and analyze a model which can be applied to a problem of hardware or software design.

**420 Computer Applications of Numerical Analysis**
Modern computational algorithms for the numerical solution of a variety of applied mathematics problems are presented and students solve current representative problems by programming each of these algorithms to be run on the computer. Topics include numerical algorithms for the solution of linear systems; finding determinants, inverses, eigenvalues and eigenvectors of matrices; solution of a single polynomial or transcendental equation in one unknown; solution of systems of nonlinear equations; acceleration of convergence; Lagrangian interpolation and least squares approximation for functions given by a discrete data set; differentiation and integration; solution of ordinary differential equations; initial value problems for systems of nonlinear first order differential equations, two-point boundary value problems; partial differential equations; finite difference grid technique for the solution of the Poisson equation.

**421-422 Numerical Analysis**
A mathematical analysis of numerical methods from the areas of solution of linear systems of equations, matrix inversion, eigenvalue and eigenvector determination, nonlinear equations, polynomial approximation, interpolation, differentiation, integration, ordinary and partial differential equations. Practical experience in the laboratory.

**435 Information Organization and Retrieval**
Covers all aspects of automatic language processing on digital computers, with emphasis on applications to information retrieval. Analysis of information content by statistical, syntactic and logical methods. Dictionary techniques. Automatic retrieval systems, question-answering systems. Evaluation of retrieval effectiveness.

**441 Mathematical Symbol Manipulations**
Deals with arithmetic and algebraic algorithms and their implementation in a generalized computer system, with emphasis on symbolic rather than numeric techniques for solutions to the problems. For each algorithm computing times will be derived and analyzed. Among the topics will be infinite precision integer arithmetic, modular arithmetic, operations on multivariate polynomials and rational functions, such as symbolic integration and exact factorization over several fields, and exact solution of linear systems.

**485 Theory of Automata I**
Automata theory is the study of abstract models of computation, both computing devices and algorithmic languages, their classification, structure, and computational power. Topics include finite state automata, regular expressions, decompositions of finite automata, Turing machines, random access machines and their abstract programming languages, halting problems, undecidability, universality, and Church's thesis.

**486 Theory of Automata II**
Topics include context-free and context-sensitive languages and their relation to pushdown and linearly bounded automata. Quantitative aspects of Turing machine computations: time- and memory-bounded computations with applications to language processing and classification of other automata and computations. Axiomatic computational complexity theory and complexity hierarchies.

**487 Formal Languages**
A study of formal languages, their processing and processors. Regular, context-free, and context-sensitive languages; their recognition, parsing, algebraic properties, decision problems, recognition devices, and applications to computer and natural languages.

**488 Theory of Effective Computability**
Notion of an effective process; Church's thesis and constructive mathematics; abstract models of computation, Turing machines; random access machines; algorithmic unsolvability; halting problems; equivalence problems; relative computability; Post's problem; degrees of unsolvability; the Kleene arithmetic hierarch; productive, creative, and immune sets; computational complexity and subrecursive hierarchies.

**517 Picture Processing**
Computer graphics and digital picture analysis. Topics include display and digitization hardware, picture data structures, preprocessing and feature detection, the receptor categorizer model of pattern recognition, linguistic methods in picture processing, mathematics of picture transformation, graphics programming languages and systems.

**521 Solutions of Nonlinear Equations and Nonlinear Optimization Problems**
The course will emphasize the rigorous analysis of practical numerical algorithms for nonlinear problems. Sample topics are nonlinear functional analysis, nonlinear curve fitting, computationally convenient modifications of Newton's method and descent methods, applications to control theory and integral equations, constrained optimization.

**523 Numerical Solution of Ordinary Differential Equations and Integral Equations**
Topics include solution of initial value problems and boundary value problems by quasi-linearization and variational techniques as well as discrete variable methods; rigorous stability analysis for standard multistep methods and modified multistep methods for stiff systems.

**525 Numerical Solution of Partial Differential Equations**
General classification; finite element techniques; solution by method of characteristics; finite-difference methods for hyperbolic and elliptic equations; parabolic equations in two dimensions; direct solution of elliptic finite-difference equations; iterative methods for the solution of elliptic equations; block methods for large systems; singularities in elliptic equations; stability in relation to initial value problems and nonlinear discretization algorithms.

**527 Introduction to Approximation Theory**
The study of the characterization of best linear and nonlinear ($L_P$) approximations to real functions, the Remez algorithm, best approximations to bounded linear functionals with applications to quadrature theory and optimal approximations.

**587 Computational Complexity**
General measures of computational complexity and methods of classifying computable (recursive) functions. Examples of topics include restricted Turing machines, time- and memory-bounded computations as well as quantitative results about formal languages.

**589 Theory of Algorithms**
Intended to acquaint students with recent research on the analysis and minimization of algorithms. The mate-

rial will include algorithms for high recision multiplication, matrix multiplication, evaluation of polynomials, discrete Fourier transforms, pattern matching, algebraic manipulation, sorting, finding medians, and manipulation of graphs. Emphasis will be on theoretical aspects of such algorithms with a view towards developing a theory of computation. Recent work of Cook, Floyd, Hopcroft, Knuth, Schönhage, Strassen, Tarjan, and Winograd will be included.

**590 Special Investigations in Computer Science**
Offered to qualified students individually or in small groups. Directed study of special problems in the field of computer science.

**591 Computer Science Graduate Seminar**
A weekly meeting for the discussion and study of important topics in the field.

**611 Seminar in Programming**

**621 Seminar in Numerical Analysis**

**635 Seminar in Information Organization and Retrieval**

**681 Seminar in Automata Theory**

See also Operations Research 9580, 9582; Electrical Engineering 4487–4488.

# Conservation

**500 Thesis Research and Professional Projects**
Limited to graduate students working on thesis research or professional master's degree projects.

**610 Conservation Seminar**
All graduate students in the Field of Conservation are expected to participate.

## Aquatic Science

**443 Ecological Aspects of Water Resources Management**
Basic structural and dynamic aspects of freshwater and estuarine ecosystems are reviewed. Nature and modes of action of stresses imposed by man on these systems and their significance to management decisions are then studied. Students will become acquainted with some of the more important laboratory and field study tools.

## Fishery Science

**439 Fish Ecology**
Interactions between fishes and their living and nonliving environment, and applications of ecological principles to fish population research and management. Population ecology; interspecific relationships of fishes including competition, predation, parasitism, and commensalism, and relationships of fishes to other organisms. Adaptations, diversity of life history and behavior patterns, and usual inhabitants of major habitat types are considered. The ecology of young fishes is stressed, and the student is introduced to the literature of fishery biology.

**440 Fishery Science**
Principles and theories involved in dynamics of fish populations. Methods of obtaining and evaluating statistics of growth, population size, mortality, yield and production, as well as investigational aspects of fishery biology are included. Laboratory will consist of field experience in obtaining and analyzing information necessary for estimating vital statistics of fish populations.

**441 Fishery Resource Management**
Principles and problems in the management of freshwater and marine fishery resources, considered in relation to problems of human population and management of other natural resources. Multiple use concepts, allocation problems, and the economic, legal, and political ingredients in solving those problems. Characteristics of fishery resources and their exploitation. Policies and techniques in managing fish stocks through maintenance and improvement of habitat, fish population manipulation, and regulation of fishing.

**494 Research in Fishery Biology**

**600 Seminar: Major Fishery Investigations**
A comparative review of major fishery investigations of the world constitutes the primary content of seminar. A study of pertinent literature and special topics will be assigned.

**601 Seminar on Selected Topics in Fishery Biology**

## Natural Resources Conservation

**415 Public Relations in Natural Resources Management**
Methods of attaining and maintaining good public relations in the natural resource management professions through the use of effective communications, the media, biopolitics, and understanding the public involved.

**420 Outdoor Recreation**
Factors involved in allocating natural resources for outdoor recreation are considered. Characteristics of public and private administration of recreation area are studied and trends in outdoor recreation explored.

**420A Field Studies in Outdoor Recreation**
A laboratory to be taken by students desiring experience with applied aspects of outdoor recreation data collection and analysis.

**421 Seminar in Remote Sensing of Natural Resources**
Characteristics of various remote sensors will be described and their sensor capability identified. Current and potential applications for sensing natural resources will be considered and simulated, and actual problems of benefit analysis undertaken.

**430 Population Dynamics of Fish and Wildlife**
Characteristics of fish and game populations and the analysis of data for purposes of projection. An examination of the processes that control the abundance of organisms. This course includes a consideration of mortality, reproductive potential, density-dependent and density- independent regulation, predator-prey and parasite-host relationships. Examples are taken mainly from areas of fishery and wildlife science. Emphasis will be placed on the practical application of course material.

**493 Research in Outdoor Recreation**

**498 Research in Resource Analysis and Planning**

**499 Research in Remote Sensing of Resources**

**510 Perspectives on Conservation**
A seminar based upon extensive readings of articles highlighting varying philosophical approaches to the conservation of natural resources. Views espoused by developmentalists, preservationists, naturalists, economists, welfare economists, and urban planners will be considered.

**511 International Natural Resources**
Seminar devoted to exploring international programs of nature conservancy; extinct and endangered species;

floral and faunal protection in various countries; national park systems; protection vs. management; the relevance of United States experience; role of nature conservancy in resource development of emerging nations. Foreign students especially are invited.

**602 Seminar in Natural Resource Analysis for Ecologically Based Planning**
Multidisciplinary graduate student-faculty-invited specialists seminar. Theme varies from year to year but usually involves a case study of a specific area of land and water. The ecological basis for planning land and water use. Engineers, economists, sociologists, soil scientists, fish or wildlife biologists, foresters, ecologists, and planners especially invited. Field work involved.

**604 Seminar on Selected Topics in Natural Resources Conservation**
Primarily for graduate students majoring or minoring in natural resources conservation.

## Wildlife Science

**304 Wildlife Ecology**
Consideration of the basic physical, physiological, interspecific, and intraspecific relationships of the organism and its environment.

**410 Principles of Wildlife Management**
Fundamental characteristics and mechanisms of wildlife population and habitats. Includes ecological, social, and economic aspects of wildlife management.

**411 Wildlife Management Methods**
Introduction to methods of management of wildlife and practical application of these techniques in the field. Intended for wildlife science majors.

**412 Wildlife Management Laboratory**
Laboratory problems in wildlife management. Involves data collecting and analysis. Intended for wildlife science majors.

**414 Advanced Wildlife Science**
Nutrition, behavior, and management of free ranging wildlife.

**495 Research in Wildlife Science**
Research work on problems of mutual interest to students and staff.

**504 Analytical Ecology**
Basic physical, chemical, physiological, and behavioral relationships between free-ranging animals and their environment are analyzed. Both domestic and wild animals are considered, with the emphasis on wild and domestic ruminants and upland game birds.

**603 Wildlife Science Seminar**
Discussion of individual research or current problems in wildlife science.

# Consumer Economics and Housing

**320 Economics of Consumption**
An investigation of economic theories and concepts relevant to an understanding of consumer choice and its role in a market economy at both the individual and aggregate levels. Empirical investigations of consumer spending and saving are examined and discussed as well as conceptual and methodological problems associated with standard budget development.

**341 Economic Aspects of Housing Consumption**
A study of the economic determinants of housing consumption and residential location, emphasizing the impact of income, population growth, financing, and the life cycle on housing demand; and the relationship between employment distribution, transportation costs, and patterns of residential location.

**345 Social Aspects of Housing in Developing Countries**
The course will emphasize an institutional approach to housing in developing countries.

**350 Introduction to Social Policy**
A study of the significance of national policies as they affect social relations and levels of living. Although it will concentrate on governmental policies, the role of private initiatives will also be considered. Questions of the distribution of social goods and services and the measurement of their contribution to particular objectives will be examined.

**355 Economic Conditions in Relation to the Welfare of Families**
Examination of contemporary economic problems that affect the welfare of families in the U.S. Examples are affluence and poverty, monetary and fiscal policies, and efficacy of the delivery of public services (health, education, subsidized housing, etc.). Where relevant, the historical origin of these problems will be studied.

**411 Time-Use Decision in Families**
Time as a human resource in a consumer-oriented society, with emphasis on its alternative uses in households. The meaning of time and implications of its use to society and to families. Critical review of research in use of time. Individual projects applied to special professional interests of students.

**425 Economics of Recreation and Leisure**
This course focuses upon the recreational use of leisure time. The framework of analysis employs a view of recreational activity as a consumer good resulting from an economic decision by the individual or household as to allocation of scarce resources—time and capital. Contributions of other social sciences will be examined, and empirical studies reviewed in terms of alternative recreation theories.

**443 The Social and Economic Effects of the Housing Environment**
A seminar considering to what extent social and economic ends may be accomplished through manipulation of the housing environment. Alternative physical and social deterministic viewpoints will be considered.

**465 Consumer and the Law**
The emphasis will be on the work of the Federal agencies and on court decisions as these affect consumers in the market.

**472 Community Decision Making**
Designed primarily for students interested in the political aspects of public policy questions at the local community level. The course will consider political participation, decision-making processes and structures, conflict, and community change.

**480 Welfare Economics**
A study of the social desirability of alternative allocation of resources. Topics include Pareto optimality, external effects in production and consumption with applications to problems of environmental quality, public expenditure decisions, measurement of welfare, and evaluation of relevant public policy issues.

**500 Special Problems for Graduate Students**

**501 Research Design and Analysis in the Social Sciences**
General introduction to the design and analysis of research. Emphasis is on research methods for social and economic studies. The meaning of science, patterns of scientific investigation in the social sciences, and their applicability to selected concepts in the departmental area.

**519 Seminar in Family Decision Making**
The process of decision making and factors related to the decision event are studied in depth.

**520 Consumption Theory**
The course presents the major developments in the micro- and the macroeconomic theory of consumption. Topics include the theory of utility and preference, substitution and income effects, absolute and relative income hypotheses, and the consumption implications of alternate growth models.

**530 Family Financial Management**
A study of developments in the family financial management field with emphasis on the role of the consultant. Each student will be expected to work with families on money management problems.

**540 Fundamentals of Housing**
Consideration of the spatial context and institutional setting of housing: the structure, operations, and performance of the housing market and the house-building industry; housing finance; the nature, operations, impact, and policy of government housing programs; contemporary housing problems and issues.

**542 Housing Market Analysis**
Basic understanding of local housing market operations and mechanisms, including demand determinants, such as demographic, economic, and institutional characteristics; supply determinants, such as the quality, nature, and expected changes of the inventory; and market indicators, such as price, vacancies, and real estate transactions. Land-use and transportation models are used as examples. A field problem is included.

**548 Social Problems in Housing**
A sociological analysis of the cultural and social determinants of the distribution of housing in society.

**549 Production of Housing**
An examination of the system of producing shelter in the United States, its structure, and major processes. Focus will be on decision making within existing institutional constraints. Description and evaluation of major subsystems. Special attention will be devoted to production of housing in conjunction with a number of special-purpose governmental programs.

**571 Community Change and Development in the United States**
A seminar addressed to the question of strategies for community change and development in a highly complex society. Topics may vary slightly from year to year, but a major purpose will be the integration of theory and practice.

**580 Applied Welfare Economics—Policy Issues**
Topics vary from year to year. The objective of the course is to evaluate the economic impact of various policies in conjunction with the efficiency of existing institutions. Policy issues covered relate to education (effects of automation, etc.), health, and environmental problems (urban development, transportation, etc.). Attention is given to the interrelationship of policy and planning within the larger economic-socio-political framework.

**597 Seminar**
Planned to orient students to graduate work in the field, to keep students and faculty abreast of new developments and research findings, to acquaint them with subject matter in related areas, and to provide opportunity to examine and discuss problems of the field.

**599 Master's Thesis and Research**

**620 Economics of Consumption**
A review of theories of the consumption function and of the recent literature on family consumption, family saving and investment, investment in human capital, and the economic determinants of the participation of women in the labor force.

**640 Seminar in Current Housing Issues**
Focuses on a selected group of national issues related to housing. The issues evaluated vary from year to year based on current importance and student interest. When possible, this course presents studies in the context of present or recent research, with emphasis on both subject content and methodology.

**643 Readings in Housing**

**658 Seminar for Doctoral Candidates**
Review of critical issues and thought in consumer economics and public policy.

**699 Doctoral Thesis and Research**

# Design and Environmental Analysis

**330 Household Equipment Principles**
Principles of operation of appliances for cooking, refrigeration, laundering, and house cleaning. Evaluation of features in relation to their intended functions and their cost.

**335 Textile Materials: Fiber Structures and Properties**
Relationship of properties of fibers, dyes, and finishes to chemical structures. Experimentation to illustrate interrelationships and chemical properties of textiles.

**342 Design: Weaving**
A studio course exploring structural processes for fabric design.

**343 Design: Textile Printing**
A studio course exploring the print as a design form.

**345 Apparel Design III: Experimental Processes**
A studio course emphasizing the relationship of structural properties of textile materials to technical processes in the development of apparel designs.

**350 Environmental Analysis: Person, Activity, Space**
Study of ways in which the physical aspects of the near environment affect a person's effort and characteristics of activities. For students specializing in product design, interior space planning, activity area planning, management of the near environment, and those aspects of consumer information programs concerned with choice of products in relation to optimal level of effort and selected characteristics of activities.

**353 Contemporary Design**
A historical study of the emergence and development of contemporary design, 1885 to the present. An examination of the social, economic, technical, and style forces which shape the design forms of the present.

**361 Residential Design**
An introduction to residential architectural design. Drafting-room work consists of plans, elevations, perspectives, and studies in the presentation of solutions.

**365 Interior Design**
Interior design problems in evaluation of design qualities of furnishings and materials. Room schemes developed in accordance with the architectural design of the house and family use.

**366 Apparel Design IV: Design Approaches**
Intended to give the student an understanding of the interrelationships of two techniques for designing apparel: draping and flat pattern.

**436 Textile Chemistry**
An introduction to the chemistry of the major classes of natural and man-made fibers, including their structure, properties, and reactions.

**438 Textiles in Fashion and Function**
Consideration of the effect of textiles in fashion and their functional role for the near environment. An integrated look at wearing quality studies and a critical review of research literature related to the performance of textile materials.

**440 Form Study: Materials**
An introduction to working with plastic forms utilizing the possibilities of clay and various processes of forming clay.

**451 History of Costume**
A comparative study of dress of selected cultures from ancient times to the end of the fifteenth century, stressing (1) the relationship of social, economic, and political factors affecting dress, and the mores as expressed through dress and (2) the contribution of ancient cultures to the apparel arts of the Western world.

**452 History of Costume**
A comparative study of dress of selected cultures from the sixteenth century through the first half of the twentieth century. Emphasis is placed on the development of the apparel arts of Western civilization and the factors which brought about change and development.

**455 Psychology of the Near Environment**
An exploration of the interaction of human beings and the immediate nonsocial environment, considered in terms of basic psychological processes including perception, learning, and motivation.

**460 Environmental Design**
The objective is two-fold: to explore the nature of our environment and to relate the physical design process to all the factors affecting our environment.

**462 Introduction to Product Design**
Introduces the student to the design of products and their relationship to human use and the environment, especially the home.

**463 Intermediate Product Design**
Emphasis is on the creation of products with relationship to materials and production methods, especially mass-production techniques.

**464 Product Development**
Intended to give the student an understanding of the role of design in the sequence of activities involved in the creation and marketing of a product.

**465 Apparel Design V: Product Development and Presentation**
Design problems requiring an advanced level of expertise in the development of products ultimately appropriate for mass production.

**466 Interior Design**
Interior design problems of varying complexities at an accelerated pace which approximates professional practice.

**467 Interior Design: Contract Interiors**
Involves the space planning and visual aspects of business and commercial interiors such as hotels, motels, public spaces, and specialized areas.

**500 Special Problems for Graduate Students**

**520 Instrumental Analysis**
An introduction to the theoretical and practical aspects of instrumentation including spectroscopy, chromatography, electrophoresis, and other selected techniques.

**530 Physical Science in the Home**
Provides background information in physical science for professionals working with equipment in teaching, extension, or home service.

**535 Textile Materials: Characterization and Evaluation**
Special consideration of the interrelatedness of the various visual, physical, and chemical aspects of problems, involving advanced physical testing of fibers and fabrics.

**536 Advanced Textile Chemistry**
An examination of the molecular structure, properties, and reactions of the major classes of natural and man-made fibers.

**538 Textiles in the Near Environment**
Consideration of environmental agencies influencing the behavior of textile materials, of important textile structure-property relationships, and of problems of shaping and setting textile articles.

**550 Man-Activity-Environment Relationships**
Man's requirements, capabilities, and limitations are studied with reference to design of man-machine systems, consumer products, interior space, and work. Review of selected literature concerned with egronomic or human-factors data and the description and measurement of work and other activities.

**555 Social Psychology of the Near Environment**
The impact of the near environment on man's behavior as a social animal. Frameworks will be developed for analyzing man's social behavior in varied settings in which he functions.

**599 Master's Thesis and Research**

**688 Seminar in Design and Environmental Analysis**
Consideration of research areas, methods, and interdisciplinary relationships.

# Development Sociology

**405 Organization Dynamics**
A study of the methods and techniques by which organization consultants, officers, group members, and administrators may increase the effectiveness of organizations. Five categories of organization problems are considered: (1) program problems, (2) leadership problems, (3) membership problems, (4) problems related to meetings, and (5) organizational and public relations problems. Organization theories are presented in relation to their uses in analysis, prediction, diagnosis, and in designing programs to bring about organizational changes.

**411 Community and Regional Development and Planned Change**
Various strategies of development and planned change will be explored. Reviewed also will be programs, organizations, agencies, and institutions operating in communities and regions that address themselves to various development strategies. Two major emphases are: (1) the structural-functional roles and processes of organizations, agencies, and institutions as they implement

programs of change and development in communities and regions, (2) roles of professionals and change agents working in development units.

**412 Rural Society**
A basic course in the sociology of rural life, using the social system concept as a theoretical framework. The development of rural society in the U.S. is used as a case to illustrate the structure and function of major rural social systems in modernized societies and the changing relationships between the urban and rural sectors. Some consideration is given to the implications of social structure and function for action programs serving rural people.

**420 Comparative Rural Societies**
The development of nations, regions, and communities is analyzed from a macrostructural perspective, emphasizing the pervasive nature of social communication and symbolic transformations. Results of recent and ongoing comparative studies are reported, and previous theoretical work relevant to structural change—Marx, Durkheim, Parsons, etc.—is reviewed.

**421 Community Structure and Change**
An overview of various models in approaching communities as objects of study. Analysis will focus on the methodologies by which power structures are examined; the relation of local community units to extracommunity systems; the forms of community cohesion and autonomy; the relation of local power structures to decision making; and the relation of changes in division of labor, urbanization, suburbanization, and values to patterns of community life.

**424 Occupations and Social Issues**
Campus unrest, crime and social disorders, and other manifestations of social unrest have focused attention on certain important institutions and related occupations, especially the teacher in the educational system, the police in the judicial system, the physician in the health services, and the social worker in the welfare structure. The interrelationship between the social structure and these occupations will be studied, with particular attention to the impact of social change and current controversies on their work environments and on the processes by which these occupations select, socialize, and reward their members.

**436 Social Movements and the Sociology of Confrontation**
To provide for maximum student participation, students under faculty supervision will plan and organize the course, which will follow a seminar format. Course content will be an interaction between available theories of collective behavior and selected comprehensive case studies. The theories of Blumer, Heberle, the Langs, Smelser, Torch, Turner, Young and others will be used to help understand selected cases from a wide range of social movements such as the Black Power movement, the National Farmers Organization, and various student movements.

**437 The Sociology of Aging**
The theory and research in this growing field will be examined. A major focus will be a critical examination of the disengagement and activity theories of the aging process. A current research project directed by the instructor will be utilized to investigate the effect of differential structural contexts on disengagement, morale, and community integration of the aged. Methodological problems in research on aging will be explored.

**440 Introduction to Computer Use**
Designed for the student who wishes to use the computer system at Cornell in his research, but not to become a programmer. The first part of the course is designed to give the student a working knowledge of the elementary aspects of FORTRAN IV and enable him to do preliminary transformations of his data and simple FORTRAN programs. The second part deals with the various "canned" programs most often used by social scientists. The student is introduced to program packages such as Michigan, Bimed, and SSP.

**443 Politics, Social Control, and Pluralism**
Comparative analyses of substantive and methodological issues in social control processes within the political economies of primarily Western democracies, but with illustrative attention to Communist and developing societies. Pluralism and control will be viewed relative to productive, allocative, and staffing processes of society, as they affect various occupational categories, communities of different size, and institutions primarily responsible for maintaining social order.

**500 Seminar: Community Development in the United States**

**510 Seminar: Decision Making and Social Action**

**511 The Metropolitan Community**
An interdisciplinary course focused upon social, political, and economic aspects of metropolitan America. Viewed from the perspectives of demography, ecology, social organization, and planning. The emergence of a new society form and its implications for contemporary America will be considered.

**515 Research Design**
An introduction to the methods of social research. Topics follow the major steps in the design and execution of sociological research from the definition of the problem and formulation of hypotheses to the interpretation of results and preparation of a final report. Practice exercises assigned each week utilize data from departmental projects.

**516 Macrosocial Research and Accounting Methods**
An introductory course in handling available data such as that produced by nations and bureaucracies for social accounting purposes, aerial photographs, ethnographic and journalistic reports, texts and documents, and reproductions of music and art. Special emphasis on macrosurveys of communities and bureaucracies, both in the U.S. and in foreign countries. Review of analysis procedures for comparative research and social accounting.

**522 Social Power and Community Decision Making**
A sociological approach in which power as an aspect of community life is examined. The methodology and the theoretical approaches of recent community power studies are analyzed. The importance of social power in community decision making and action programs is considered, and the influence of community power structures in instigating and retarding change is analyzed.

**528 Applications of Sociology to Development Programs**
Application of sociological theory and methods to the problems of institutions and agencies concerned with rural development. Special emphasis is placed on programs for agricultural extension education and community development in low-income countries.

**550A Informal Study**
Rural Sociology.

**550B Informal Study**
Development Sociology.

**550C Informal Study**
Organization Behavior and Social Action.

**550D Informal Study**
Methods of Sociological Research.

**551A Research**
Rural Sociology.

**551B Research**
Development Sociology.

**551C Research**
Organization Behavior and Social Action.

**552 Teaching Experience**

**553 Public Service Experience**

**624 Seminar: Macro Systems Theory**

**630 Seminar: Contemporary Social Theory I**

**631 Seminar: Contemporary Social Theory II**

**636 Seminar: Social Change and Development**

**651 Seminar: Occupational Structure**

# Ecology and Evolutionary Biology

All courses carry Biological Sciences numbers unless otherwise indicated.

**261 Introductory Ecology**
A basic grounding in the principles of ecology as a fundamental science. (Students concentrating in this Field must take Biological Sciences 361 instead of this course.) Topics will include the growth and limitation of populations, interactions between populations, the structure of communities, and the flow of energy and cycling of materials in ecosystems. The ecological effects of human overpopulation and its attendant problems will also be discussed.

**273 The Vertebrates**
An introduction to the evolution, classification, comparative anatomy, life history, and behavior of vertebrate animals. Laboratory dissection, experimentation, and demonstration are concerned with structure, classification, systematics, biology of species, and studies of selected aspects of vertebrate life.

**344 Biology of the Algae**
An introduction to the freshwater and marine algae, including consideration of their ecology as members of the plankton and benthos and their importance to man. The laboratory, utilizing field material and cultures from an extensive living collection, is designed to illustrate lecture topics, provide familiarity with algae in the field, and introduce the student to techniques used in isolating, culturing, and studying algae in the laboratory.

**361 General Ecology**
Principles concerning the interactions between organisms and their environment. Influence of competition, social behavior, predation, and other factors on population size and dispersion. Role of energy flow and mineral cycling in determining the structure and productivity of ecosystems. Succession and classification of natural communities. Influence of climate and past events on the diversity and stability of communities in different regions of the world. Interspecific competition and the niche concept. Chemical interactions between organisms. Application of ecological principles to human problems. Modern evolutionary theory will be stressed throughout and attention given to conflicting ecological hypotheses.

**364 Field Marine Biology**
This special course offered on Star Island, off Portsmouth, N. H., in June, emphasizes living material and habitats in introducing students to the major disciplines of marine biology and rounding out their knowledge of these topics as presented at inland locations. For more details, see the *Announcement of the Summer Session* or consult Mr. Kingsbury.

**371 Evolution and Taxonomy of Vascular Plants**
An introduction to the evolution and classification of vascular plants, with attention to principles, methods of identification, and literature. In the first part of the term, trips are held in laboratory periods.

**461 Oceanography**
Physical and chemical aspects of the marine environment and interactions with marine communities. Laboratories devoted to demonstrations of field and laboratory techniques, experiments with simple models, and interpretation and analysis of typical oceanographic data.

**462 Limnology**
A study of the interaction of biological communities and their aquatic environment. Lectures deal with the physical, chemical, and biological dynamics of freshwater ecosystems. Laboratories devoted to both field studies and experiments on model systems.

**462A Limnology Lectures**
The lecture portion of course 462.

**463 Plant Ecology**
Principles of plant-environment interactions in relation to the distribution, structure, and functioning of plant communities. These principles will be illustrated by analyzing in the field representative plant communities and their environments.

**464 Evolution and Ecology of Vascular Plants**
A study of the variation, evolution, and ecological distribution of vascular plants. Laboratory periods in the later part of the term are devoted to study of natural populations in the field.

**466 Chemical Ecology**
Ecological and evolutionary significance of chemical interactions between organisms. Summary of key processes in regulation of natural populations. Survey of major classes of natural products with emphasis on appropriate analytical techniques. Chemical adaptations for reproduction, defense, habitat selection, dispersal, feeding efficiency, and competition in animals, plants, and microorganisms. Choice of adaptive strategy in relation to energy flow. Practical applications of chemical ecology.

**467 Species Distribution and Abundance**
An advanced course emphasizing the unifying principles of ecology, biogeography, and population biology. Topics include the distribution of organisms in time and space, biogeographic regions, continental and island patterns of distribution, ecology of dispersal and colonization, ecological, and genetic considerations of population structure, and factors determining population size. Includes projects and exercises designed to give students first-hand contact with field techniques and data analysis.

**469 Biology of Fishes**
An introduction to the study of fishes; their structure, classification, evolution, distribution, ecology, physiology, and behavior. Laboratory studies on structure, identification, classification, and nomenclature. Field studies of local species.

**470 Ichthyology**

**471 Mammalogy Lectures**

**471A Mammalogy Laboratory**

**472 Ornithology**
Lectures cover various aspects of the biology of birds including anatomy, physiology, classification, evolution,

migration and orientation, behavior, ecology, and distribution. Laboratory will include studies of external and internal morphology, pterylosis, molts and plumages, skin identification of birds of New York and families of birds of the world. Several demonstration periods will emphasize hybridization, evolution, adaptive radiation, mimicry, and geographic variation. Field work includes identification of birds and familiarization with some techniques used in field research.

**474 Herpetology Lectures**
Lectures on evolution, classification, distribution, and adaptations of reptiles and amphibians. Emphasis on ecology, behavior, and environmental physiology.

**474A Herpetology Laboratory**
Laboratory and field work on systematics, ecology, behavior, and physiology of amphibians and reptiles. In the second half of the semester the class may be divided into several groups which will concentrate on different projects.

**475 Evolutionary Theory**
Lectures and class discussions on organic evolution, with primary emphasis on the mechanisms of speciation and adaptation. The course begins with a few lectures on taxonomic methodology.

**480 Population Genetics**
A study of factors which influence the genetic structure of Mendelian populations and which are involved in race formation and speciation.

**512 Comparative Physiology Lectures**

**512A Comparative Physiology Laboratory**

**561 Quantitative Ecology**
A quantitative course on selected ecological topics, including the origin and interpretation of habitat differences, toleration and response physiology, population dynamics, construction and uses of life tables, spatial distribution patterns, and approaches to the quantitative analysis of biotic communities.

**564 Advanced Plant Ecology**
Seminars dealing with either (*a*) physiological mechanisms and the physical, chemical, and biological processes which underlie the distribution of plants and communities, or (*b*) structure, function, and theoretic interpretation of plant communities. The seminars may be offered concurrently; both may be taken.

**565 Special Topics in Limnology**
Primarily a seminar course. Advanced discussion and experimentation in specific topics, which vary from year to year.

**566 Marine Ecology**
Lectures will present a survey of current topics in biological oceanography, including biogeography, ecosystems, marine resources, and environmental problems. Laboratory will consist of demonstration of common chemical and biological methods with the last few weeks devoted to interpretation of typical oceanographic data.

**566A Marine Ecology, Field Work**
An application of common sampling and observational techniques in Biological Oceanography. Students will be expected to become proficient in one or several techniques which will be employed on a one-week cruise on an oceanographic vessel sometime during the term. Remainder of the term will be devoted to completion of analyses and preparation of a report on the cruise.

**571 Special Topics in Higher Vertebrates**
Seminars on selected topics of vertebrate ecology, behavior, physiology, and systematics, with an emphasis on review of current literature.

**572 Special Topics in Lower Vertebrates**
Detailed consideration of selected topics in comparative physiology. Preparation of demonstration experiments stressing technique and individual research problems will be included. Topics vary from year to year.

**595 Environmental Biology**
Attention is focused on ecology and environmental quality.

**661 Seminar in Population and Community Ecology**

**662 Ecology of Pest Management**
The focus will be on the ecology of pest management for the development of safe, effective population control measures. The "Systems Approach" to the management of pests (insects, algae, weeds, animal and plant pathogens, birds, and mammals) will be emphasized. Combinations of biological, physical, and chemical means for pest management will be discussed.

**663 Seminar in Evolution and Ecology of Vascular Plants**
A consideration of primary problems concerned with the classification, evolution, and environmental relationships of vascular plants.

**665 Environmental Physiology**
Consideration of the responses of organisms to environmental variables. Emphasis on similarities and differences in molecular and organismal mechanisms by which plants and animals cope with their environments.

**666 Population Ecology**
Critical examination of the properties and dynamics of populations. Emphasis on theories of population structure, dynamics, and regulation. Discussion of experimental approaches to analyses of natural populations.

**667 Ecology Core Course III. Communities**

**668 Ecosystems**

**900 Vertebrate Morphology**
Designed for graduate students in Animal Science, Biological Science, Nutrition, and Conservation. A dissection of the dog serves as the basis for a functional consideration of the component parts of mammalian organ systems. This is followed by a dissection of the fetal and adult cow. Other species of interest to the class are also presented. Demonstrations, films, and student presentations are included throughout the term.

**Agronomy 306 Soil Microbiology**
A study of the major groups of soil microorganisms, their ecological interrelationships, and the biochemical functions of the soil population.

**Agronomy 307 Soil Microbiology, Laboratory**

See also Agronomy 404, 506; Conservation 439; Entomology 331, 351, 531, 532, 533, 534, 551, 553, 672; Microbiology 492; Neurobiology and Behavior 421, 523, 622; Plant Pathology 309.

# Economics

**509 The Theory of Household and the Firm**
The first semester in a two-semester sequence in microeconomic theory. This course concerns the decision processes of individual firms and individual consumers. Individual and aggregate demand and supply

relations are derived. Other topics discussed include uncertainty and capital theory.

**510 The Theory of Markets and General Equilibrium**
The functioning of the markets for goods including the cases of pure competition, monopoly, duopoly and monopolistic competition. The markets for factors of production: labor, land, capital, and entrepreneurship. The theory of general equilibrium and welfare economics. Pareto optimality. The theory of the second best. Nonmarket decision making.

**511 Microeconomic Theory**
A one-semester introduction to microeconomic theory. Topics include the theory of consumer behavior, theory of the firm, theory of markets, general equilibrium, income distribution, and welfare economics.

**512 Macroeconomic Theory**
A less extensive treatment of many of the topics in Economics than 513, 514—consumption, investment, the demand for money, static income determination, cyclical behavior, and inflation.

**513 Macroeconomic Theory: Static Income Determination**
Consumption, investment, the demand for money, and static income determination.

**514 Macroeconomic Theory: Dynamic Models, Growth and Inflation**
A continuation of 513, dealing with economic fluctuations, inflation, theories of growth and optimal growth and "short-run growth" models.

**517 Intermediate Mathematical Economics**
No prior acquaintance with the mathematical topics covered is required. Economic subjects will include economic models, static or equilibrium analysis, comparative-static analysis, optimization of objective functions subject to constraints, production functions. Mathematical topics will include functional dependence, set theory, linear models and matrix algebra, derivatives and differentiation, partial derivatives, differentials, tests for extreme values, maxima and minima subject to constraints, homogeneous functions.

**518 Intermediate Mathematical Economics**
Economic subjects will include Domar and Solow growth models, the Domar debt model, cobweb models, the Samuelson multiplier-accelerator model, dynamic input models, linear programming models and their duals. Mathematical topics will include integration, differential equations, simultaneous equation models, linear programming, game theory.

**519 Quantitative Methods**
Topics will include a brief review of frequency distributions, probability distributions, hypothesis testing and interval construction, followed by a more detailed examination of multiple regression, various problems with error terms, identification and simultaneous equation estimation.

**520 Quantitative Methods**
The application of quantitative analysis to testing of economic theories will provide a basis for study and evaluation of cross-section and time-series data, methodology and theory of economic measurement, statistical techniques, empirical studies, and economic forecasting.

**521-522 European Economic History**
An examination of significant processes and relationships in the economic development of Europe in the ancient and medieval periods. Attention will be given to reciprocal relationships between the social and political context and the behavior of the economy over time.

**523-524 American Economic History**
The course will concentrate on three lines of investigation: the use of economic and statistical analysis as an aid in answering historical questions; the use of historical experience in determining the validity of aspects of economic theory; and the extent to which historical economic experience is useful in resolving current economic problems. Problems selected from the period 1800–1939 will be discussed.

**525 Economic History of Latin America**
A survey emphasizing the processes and problems of economic growth and the evolution of economic institutions.

**527 The Environment of Economic Activity in Postwar Europe**
Economic growth and change in postwar Europe, with special emphasis on the business system and the role of the state. Topics will include the sources of economic growth, the role of management, labor and consumers, planning versus competition, integration and trade liberalization, the impact of the U.S. and regional development. Concentration on Western Europe.

**529 Economic History of Early Modern Europe**
An examination of the major processes of economic and social change in the postmedieval, preindustrial period.

**561 International Economic Theory and Policy**
Survey of the principles that have guided the formulation of international trade and commercial policies. The evolution of the theory of international trade, principles and practices of commercial policy, problems of regional integration and customs unions, and institutions and practices of state trading will be emphasized.

**562 International Economic Theory and Policy**
Survey of the principles that have guided the formulation of international financial policies. The evolution of the theory of balance-of-payments adjustment, international monetary standards, the nature of conflicts arising out of the relationship between domestic economic policies and external economic relations, international capital movements, economic aid, international monetary institutions, and proposals for international monetary reforms will be emphasized.

**565 Economic Problems of Latin America**
A survey of current economic policies and performance in Latin America, with special attention to inflation, balance of payments, economic integration, plan implication, and income distribution.

**567 Comparative Economic Systems: Soviet Union and Europe**
Discussion of the rationality and feasibility of economic planning (von Mises, Hayek, Lange). Examination of the various approaches to planning, including discussion of the planning techniques in France, Yugoslavia, and especially the Soviet Union. Comparison of economic performance of various free and planned economies. Consideration of economic competition between the free and the planned systems.

**571 Economic Development and Sociopolitical Modernization**
An effort to view the development of low-income countries as both an economic and a noneconomic process. The relevance and limitations of conventional economic analysis are explored, together with the problems of bringing about institutional change. Attention is paid to the role of established power in preserving basic in-

stitutions and to the emergence of opposed power systems as necessary to their modification.

**572 Processes of Economic Growth and Development**
A consideration of various contributions by economists and others to an understanding of how societies undergo economic growth and institutional change. Developing countries are the main focus of attention, with emphasis on Africa. Some possibilities of combining elements from economics and other fields to form a broad approach to economic development are explored.

**575 Economics of Poverty**
An examination of poverty in the U.S. today (urban and rural) in relation to the functioning of the economy and its long-run development. Implications of official statistical definitions and measurements of "poverty". Evolution of social and political attitudes towards poverty. Evolution and economic impact of various governmental policies, including "War on Poverty".

**576 Sociopblitical Modernization**
Resembles course 571, but with less emphasis on conventional economic analysis.

**582 The Participatory Economy of Yugoslavia**
Examines the worker-managed economy of Yugoslavia. The organization and the theoretical and practical implication of worker management will be studied in detail. Special attention will be given to the outcomes of the decision-making process at the firm level of such a system, the dovetailing of these outcomes with the national plans, and the policies used to implement them.

**611 Advanced Microeconomic Theory**

**612 Advanced Macroeconomic Theory**
The theory of dynamic stability, cyclical fluctuations, and growth of aggregate economic activity.

**613-614 History of Economic Thought**
Extensive reading in and discussion of books that have been significant in the development of economic thought. Emphasis on mercantilism and the classical reaction to it through Marshall. A term paper is required.

**617-618 Mathematical Economics**
A rigorous approach to the problem of general equilibrium analysis is presented. The following subjects are treated mathematically: demand theory, stability of equilibrium, pareto optimality, existence of equilibrium, and capital accumulation.

**619-620 Econometric Theory**
Systematic development and discussion of statistical methods used in testing relationships among economic variables. Brief review of mathematical statistics, probability theory, and matrix algebra. The classical linear regression model will be discussed and its several assumptions will be weakened in turn, followed by discussion of systems of equations, their properties, and the methods of estimating such systems. At the end of 620, an overview will be given of other econometric techniques such as factor analysis and spectral analysis. Although some applications will be discussed, emphasis is on the theoretical framework of econometrics.

**619A-620A Workshop in Econometrics**
Will include three different types of activities: discussion of special topics in econometric theory, model building, and quantitative formulation of economic policy; discussion of students' own research (including thesis work) in the quantitative areas; and discussion of research of the instructor and possibly other faculty members.

**621-622 Seminar in Economic History**
Topics will be selected in keeping with the interests of the participants.

**623-624 American Economic History**
Problems selected from the period 1800–1939 will be discussed.

**631-632 Monetary Theory and Policy**
Topics in monetary theory and policy.

**635-636 Public Finance: Resource Allocation and Fiscal Policy**
The effects of taxation on resource allocation, with theoretical analysis and application to the American tax structure. A short introduction to expenditure theory.

**641-642 Labor Economics**
Reading and discussion of selected topics in current labor economics in the fields of theory, institutions, and policy.

**651 Industrial Organization**
Essentially a course in the theory of the firm. Motives of entrepreneurs and managers are discussed, e.g., profits, sales, growth, satisficing, etc. Traditional pricing decisions in oligopolistic and monopolistic markets are reviewed, along with the basic theory of markets. The determinants and effects of major investment decisions are discussed (capital equipment, R&D, advertising and mergers). Heavy emphasis is placed on existing empirical tests of the various hypotheses of firm behavior.

**652 Industrial Organization and Regulation**
Beginning with a discussion of the goals of a free-enterprise economy, the course will examine the role of government in achieving those goals. The various tools of government control such as antitrust laws, regulation, and public ownership will be examined in some depth and evaluated. Conditions of market failure, in a variety of market situations as in education, conservation, and health will be discussed in the context of designing public policies to improve economic welfare.

**661-662 International Economics: Pure Theory and Policy**
Alternative theories of international barter exchange, international trade and factor remuneration, the transfer mechanism, theory of gains from trade, trade under imperfect market conditions, trade and economic growth, and related subjects.

**663-664 International Economics: Balance of Payments and International Finance**

**666 Special Topics in International Finance**
An intensive examination of the theory of forward exchange and short-term capital movements, the Eurodollar market, the theory of internal-external equilibrium, and other topics.

**671-672 Economics of Development**
Exploration of basic issues in economic development; emphasis will depend upon the instructor. Topics will be selected from such areas as economic growth theory, the relationship of international specialization and economic development, interaction of culture and modernization, and policy issues in economic development.

**674 Economic Growth in the Soviet Union and Eastern Europe**
The periods covered will be the N.E.P., the centralized integral planning, and the current K.B. reforms. Application of the Soviet model to the East European coun-

tries will be considered together with the current reform movements.

**675 Growth and Development**
The primary focus is upon theory of economic development; descriptive and normative models of economic growth will be discussed.

**676 The Economy of China**

**677 Topics in Economic Growth and Development**
A critical review of the basic literature concerning investment, growth, and development in less developed countries. Emphasis is placed on the broadening scope of analysis in recent years and the reasons it is necessary.

**678 Economic Growth in Southeast Asia**
Analysis of the processes and patterns of economic growth in Southeast Asia. Emphasis on comparative analysis of institutions and policies for accelerating growth. Survey of economic nationalism, the relationship of agricultural development to industrialization, international specialization and economic development, and the economic role of the state in Southeast Asia.

**679 Theory of Economic Development**

**681 Economics of Participation and Labor-Managed Systems: Theory, Policy, and Planning**
The theory of labor-managed economies is systematically developed and literature on that and related subjects surveyed. Theories of the participatory firm, industry, and general equilibrium are covered together with the macroeconomic theory and analysis of special dimensions of the system. Efficient decision-making processes within the firm are also studied. Illustrative references to Yugoslavia and other real instances of labor participation are made throughout.

**682 Economics of Participation and Labor-Managed Systems: Economic and Planning**
Using the theory developed in 681, this course studies the role and mechanics of economic policy and planning in a participatory economy. The growth potential of that economy is also analyzed in the context of modern theory of economic growth.

# Education

## Agricultural Education

**432 Methods, Materials, and Directed Practice in Teaching Agriculture in the Secondary School**
Direct participation in off-campus centers in the problems of teaching agriculture on the junior and senior high school levels, which include adjustment in the school and community; evaluation of area resources, materials of instruction, and school facilities; organization and development of courses of study; launching and directing work experience programs; planning for and teaching all-day classes, advising occupational youth organizations; and other problems relating to development of a balanced program for occupational education in agriculture in a local school or area occupational center.

**433 Special Problems in Agricultural Education**
The purpose is to provide students with an opportunity to study, individually or as a group, selected problems in agricultural education to meet their particular needs.

**434 Organization and Direction of Out-of-School Programs**
Emphasis will be placed on solving the problems encountered by teachers of agriculture in such phases of the out-of-school program as making arrangements to have a program, determining instructional needs and planning programs of instruction, teaching in groups, giving individual instruction, organizing and advising the local association, and evaluating the out-of-school program.

**531 Supervision in Agricultural Education**
The function of supervision, program planning, and supervisory techniques as applied to state programs in agricultural education.

**532 Advanced Methods and Materials of Teaching Agriculture**
Consideration is given to selected teaching techniques and to the selection, preparation, and use of instructional materials.

**533 Planning Courses of Study and Agricultural Experience Programs**
Guiding principles, objectives, and sources of information will be developed for planning the courses of study and teaching calendar. Consideration will be given to principles, meanings, and functions of agricultural experience programs and how they are planned, developed, and used.

**534 Education for Leadership of Youth and Adult Groups**
A consideration of the principles involved in organizing and conducting out-of-school programs for youth and adults.

**535 Planning and Conducting Programs of Teacher Preparation in Agriculture**
Open to persons with teaching experience in agriculture who are preparing for or engaged in the preparation of teachers or related educational service.

**536 Organization and Administration of Agricultural Education**
Designed for teachers, high school principals, teacher trainers, supervisors, and others who are or wish to become administrators of agricultural programs. Emphasis will be placed on interpreting vocational acts and on problems of local and state administration.

**539 Evaluating Programs of Agricultural Education**
Students will study objectives and evaluate and develop criteria and procedures for evaluation of programs of agricultural education in the secondary schools.

**630 Seminar in Agricultural Education**
Recommended for Master's degree candidates who have had teaching experience and doctoral candidates with majors or minors in agricultural education. Primarily centered in current problems and research not included in other course work.

## Community Service Education

The following courses are taught in the Department of Community Service Education, New York State College of Human Ecology.

**CSE 500 Special Problems for Graduate Students**

**CSE 502 Organization of Community Services**
The course focuses on the comparative analysis of community services. Attention will be directed to assessment of the need and the development and use of community resources, particularly in relation to their educational function. The relationship among families, community services, and the governmental structure will be examined, as well as the roles and interrelationships of individuals and groups within these systems. Effectiveness of the delivery of these services in relation to their functions will also be discussed.

**CSE 503 Exploration in Individual Behavioral Change**
A systematic analysis of theories of individual behavioral change and the learning process. Introduction to facilitative processes in the helping relationship; emphasis will be placed upon the theories and dynamics of behavioral change, role definition, self-understanding, and personal growth. Discussion of one-to-one helping techniques, role playing, and dyad and triad experiences.

**CSE 504 Identification and Use of Intervention Strategies with Individuals and Groups**
Concepts related to planned change; the change agent; the client system; application of valid knowledge to the client's problems; mutual goal setting; planned action; change agent-client relationships. Types of strategies for behavioral and organizational change. Mechanisms of change and the role of the change agent; creating motivation to change, determining family and individual goals, developing new responses; identifying components of behavior and level of achievement required for individual change; stabilizing and integrating change; relationships between individual and organizational change; value dilemmas of the change agent. Students will undertake a relevant field problem.

**CSE 510 Seminar in Adult Education**
Deals with a significant problem area in adult education, such as philosophy of adult education, the teaching-learning process for adults, or special problems of the disadvantaged adult learner. Implications of theory and research in the problem area will be important considerations. The particular area to be considered will be announced at preregistration time.

**CSE 516 The Facilitative Processes and the Helping Relationship**
Concentration on theory and research in facilitating the helping relationship. Each class member will participate in a group laboratory to develop helping skills and will undertake a research project in the area.

**CSE 530 Seminar in Human Services Training**
Weekly seminar and independent study related to the training of paraprofessionals in human services; training of professionals and the service team; development of job opportunities and career ladders; development and evaluation of appropriate curricula and teaching-learning techniques; development of linkages with community agencies and other institutions of higher education; and evaluation of progress toward each of these goals.

**CSE 531 Supervision of Paraprofessionals in Human Services**
For persons who anticipate working with paraprofessionals in community service settings. The course will focus on the nature of professionalization; roots of paraprofessionalism; the New Careers concept; models of utilization of paraprofessionals; recruitment, selection, training, and evaluation of paraprofessionals; and team-building skills required by the professional. Attention will also be given to organizational practices that facilitate differentiated staffing.

**CSE 550 Comparative Studies of Family Education Services**
Factors related to the development of educational programs for improving family living conditions in differing cultures. Analysis of needs and evaluation of methods of approach in countries at varying levels of development.

**CSE 580 Seminar in Community Service Education**
An informal seminar for graduate students and faculty. One or two major topics related to community components and dynamics or the provision of educational services will be considered each term.

**CSE 599 Master's Thesis and Research**

**CSE 620-621 Strategies for Community Change**
The application of behavioral science theory and method to planned organizational change. Strategies of social change and their application to community situations: collaboration, conflict, and resistance. Field observation in community situations undergoing planned change and analysis of strategies in process. Second semester taken in conjunction with field experience in community. Opportunity to participate in change process and evaluation research on ongoing community project study of human problems related to community change, e.g., housing, education, and health. Experience in diagnosis of ongoing problems related to community change and in planning appropriate intervention strategies.

**CSE 625 Internship**
Assignment to an agency or institution which provides opportunity for participation in planning, implementation, and evaluation of the ongoing program.

**CSE 699 Doctoral Thesis and Research**

See also CSE 584, 590, and 690 under Home Economics Education.

## Curriculum and Instruction

**444 Seminar in the Teaching of Secondary Mathematics**
Materials and methods for teaching mathematics in the junior and senior high school. Attention will be given to research in mathematics education and recent proposals for curriculum revision.

**445 Teaching Reading and Study Skills in Secondary Schools**
For teachers, administrators, guidance counselors, and supervisors. Pertinent research as well as the psychology and philosophy of developmental reading and study skills will be examined. Teaching methods and sample materials for classroom use will be demonstrated and discussed.

**540 The Art of Teaching**

**542 Seminar in Secondary Education**

**545 The Curriculum of American Schools**
A survey of the basic elements involved in making curriculum decisions, and an examination of contemporary curriculum developments in elementary and secondary schools.

**546 Teaching Reading and Language Skills**
Materials and techniques in teaching the language arts in the elementary schools; special emphasis on the teaching of reading.

**547 Seminar in Elementary Education**
A study of current problems and research.

**549 Seminar in the Teaching of Elementary Mathematics**

**645 Seminar in Curriculum Theory and Research**

See also 407 and 509 under Science and Environmental Education; 532 and 533 under Agricultural Education; 565 under Educational Administration; and 572 and 584 under Home Economics Education.

## Educational Administration

**561 Administration of Educational Organizations**
A consideration of current approaches to understanding

administration and organizations, and their application to the educational setting.

**562 The Principalship**
Analysis will include the elementary and secondary school as institutions, innovation in organization and curriculum, personnel administration, and community relationships. Each student will specialize at the elementary or secondary school level for an individually planned program of intensive study.

**563 Sociology of Education**
Introduction to major themes in the contemporary literature in the sociology of education. These include social stratification and education, the school as an organization and as an institution, minority groups in the school, socialization, professionalization of teaching, bureaucratization, the teacher–student roles, and the career patterns of teachers.

**564 Economic Issues in Education**
Introduction to problems of resource procurement and allocation, with focus on existing and alternative strategies of fiscal support for schools and new management techniques for allocating such resources.

**565 Supervision of Instruction**
A basic course in supervision; fundamental principles and various procedures.

**567 Education Law**
Review and analysis of federal and state legislation, court decisions, opinions, and regulations which affect educational institutions.

**569 Personnel Administration**
An introduction to modern psychological and sociological perspectives of personnel administration. The purposes are to acquaint the student with a variety of ways of conceiving the problems of personnel administration and with relevant research, and to develop some facility in the analysis of conceptual schemes and research projects.

**668 Seminar in Educational Administration**

## Educational Psychology and Measurement

**411 Educational Psychology**
Consideration of the outstanding facts and principles of psychology bearing upon classroom problems.

**417 Psychology of Adolescence**
A survey of the nature of adolescent growth and development with emphasis on some of the causal factors in adolescent behavior.

**511 Educational Psychology**
A basic course in educational psychology for graduate students.

**551 Educational Measurement**
A study of the construction of achievement tests and of the use of aptitude tests, achievement tests, and other measuring instruments in the classification and guidance of pupils and improvement of instruction.

**555 Use and Interpretation of Tests in Guidance and Personnel Administration**
Deals with the historical development, use, and interpretation of aptitude tests as a basis for guidance and selection in public schools, colleges, and/or industry. Designed to meet the New York State certification requirements for guidance counselors.

**613 Seminar in Educational Psychology**
Theoretical issues in the area of reading.

**617 Seminar in Learning and Memory**
Current issues in the learning, retention, and transfer of verbal information.

**618 Seminar in Educational Psychology**
Emphasis on theoretical considerations of various areas in educational psychology.

See also 452, 453, and 599 under Educational Research Methodology.

## Educational Research Methodology

**452 Interpretation of Statistics Used in Education**
A brief introduction to the vocabulary and symbolism used in reporting empirical research in education. Both univariate and multivariate statistical procedures will be covered from an intuitive point of view.

**453 Introduction of Educational Statistics**
Common statistical procedures encountered in educational literature and research. Includes the mathematical bases, computation, and interpretation of univariate and multivariate descriptive and inferential statistics.

**599 Methods of Educational Inquiry**
An introduction to the methods that underlie the conduct of significant empirical research in education. Emphasis will be placed upon describing and analyzing such procedures as forming concepts, developing educational products, making observations and measurements, performing experiments, building models and theories, providing explanations, and making predictions.

**616 Seminar in Educational Psychology**

**698 Practicum in Educational Research**
Participation in a research project under the direction of the principal investigator of the project. Level of responsibility will increase with the experience and capability of the candidate, the eventual goal being his assumption of responsibility for a portion of the research.

**699 Conceptual Problems in Educational Inquiry**
An examination of such concepts as causation, operationism, validity, reliability, hypothetical constructs, generalization, explanation, probability, and hypothetico-deductive method.

See also 527 under Extension and Continuing Education; 551 under Educational Psychology and Measurement; CSE 690 under Home Economics Education; and Psychology 407 and 475.

## Extension and Continuing Education

**522 Educating for Community Action**
Emphasizes design and execution of educational aspects of community action programs. The course deals with identification and statement of educational goals, selection of teaching strategies and evaluation of outcomes.

**523 Administration of Continuing Education Programs**
Application of the principles of administration and supervision to organization and operation of continuing education programs.

**524 Designing Extension and Continuing Education Programs**
Analysis of current theories, concepts, principles, and procedures central in the process of developing programs for the continuing education of adults. Emphasis is on such major problems as situation analysis, leader-

ship objectives from alternatives, creating support at macro level, organizing program resources at micro level, and planning for program execution.

**525 Educational Communication With Adult Audiences**
Emphasizes the centrality of useful technology and its effective communication in continuing education programs. Emerging models of the communication process are reviewed as a framework for analyzing the major elements of the communication process with adult audiences, including communicator credibility, program content, messages, transmission channels, message treatment, audience identification, feedback, and the design of operational communication programs.

**526 Practicum in Extension and Continuing Education**
Provides opportunity for students to supplement the formal aspects of their curriculum through systematic participation in an ongoing continuing education program.

**527 Evaluation for Program Management**
Program evaluation is treated as a part of the overall task of making program management decisions. Primary attention is given to educational and other community change programs, but references to other program management tasks are possible.

**626 Seminar in Extension and Continuing Education**
Provides opportunity for divisional students and staff jointly to analyze and reflect on current professional issues.

**627 Seminar: Behavioral Change in International Rural Modernization**
Analysis of concepts and strategies for repatterning human behavior at both the macro and micro levels. Changes in human behavior are viewed as a dependent variable in the rural development process.

**628 Seminar: Current Problems and Issues in Extension Education**
A major area of concern to extension education will be selected for intensive study.

## Guidance and Student Personnel Administration

**580 Student Culture in the American College**
A study of the student culture with emphasis on current research.

**581 Student Personnel Administration**
Analysis of objectives, function, and organization of student personnel services in higher education. Emphasis on behavioral science theories supporting student personnel administration.

**582 Educational and Vocational Guidance**

**583 Counseling**
The counseling process viewed from selected theoretical systems. Differentiation of the counselor's role and counseling objectives between systems, through the use of case studies.

**584 Group Counseling**
Techniques and principles of counseling with groups will be examined in terms of the role of the counselor in achieving desired outcomes.

**585 Occupational and Educational Information**

**586 Organization and Administration of Guidance Programs**

**587 Practicum in Measurement and Appraisal for Counselors**

**588 Case Studies in Counseling**

**602 Field Laboratory in Student Personnel Administration**

**681 Seminar in Student Personnel Administration**

The following courses, not ordinarily given on campus during the academic year, are offered in alternate summer sessions.

## History, Philosophy, and Sociology of Education

**470 Educational Issues**
A critical examination of theories, policies, and practices.

**471 Logic in Teaching**
A consideration of definition, explanation, proof, and the nature of knowledge as they bear upon classroom teaching.

**472 Philosophers on Education**
Selected writings by such philosophers as Plato, Descartes, Rousseau, and Dewey, and some contemporary writers, will be examined in their own right and for the light they throw on persistent problems in education.

**473 Contemporary Philosophy of Education**

**574 History of American Education**
An examination of the role of education in shaping American society. Chief emphasis will be on the period from 1820 to 1914.

**578 Comparative Education**
A comparative treatment of several national systems of education from a historical perspective.

**598 Education as a Field for Inquiry**
Designed primarily for students without previous training or experience in the field of education, this course is intended to provide insight into the nature and content of the field to which their research efforts will be directed. It will cover the structure of the educational enterprise, its history, its objectives and the ways it seeks to achieve them, its main concerns, emphases, and sources of strain.

**670 Seminar: The College and University**
Conditions of disciplined inquiry in higher education.

**671 Seminar: Analysis of Educational Concepts**
Liberalism. Studies of ideologies and educational policies.

**672 Seminar: Educational Classics**

**673 Seminar: John Dewey**
Primary aim is a critical understanding and appraisal of Dewey's philosophy, especially as it centers upon education.

**674 Seminar: History of Education**

See also 563 under Educational Administration and 699 under Educational Research Methodology.

## Home Economics Education

The following courses are taught in the Department of Community Service Education, College of Human Ecology.

**CSE 500 Special Problems for Graduate Students**
For students recommended by their chairmen and approved by the instructor in charge for independent, advanced work.

**CSE 571-572 The Teacher Educator in Home Economics**
For students preparing for teacher education positions involving supervision of student teachers.

**CSE 579 The Teaching of Home Management in College**
An examination of the ways home management concepts are currently being taught and the exploration of new approaches.

**CSE 584 Curriculum Development**
An examination of the social, psychological, and philosophical bases of curriculum theory with special attention to techniques presently used in curriculum development. Opportunity for students to work on individual or group projects related to their interest and expertise.

**CSE 590 Evaluation**
Basic principles of evaluation studied in relation to specific methods of appraising progress toward objectives of behavioral change. Opportunities will be given for constructing and using evaluation instruments.

**CSE 599 Master's Thesis and Research**

**CSE 673 Internship and Field Work in Teacher Education**
Involves supervision of student teachers and conferences as needed with college supervisor and cooperating teachers in the schools. Provision made for a follow-up visit to a first-year teacher.

**CSE 690 Seminar in Evaluation**
Opportunity for intensive study of literature concerning selected topics in evaluation, for refinement of appraisal techniques, and for carrying out an evaluative study related to current departmental research.

**CSE 699 Doctoral Thesis and Research**

See also courses listed under Community Service Education within the Field of Education.

## Science and Environmental Education

**401 Our Physical Environment**
A study of the commonplace phenomena and substances in our physical environment, and their use in demonstrating basic scientific principles. Frequent field trips and first-hand examination will be used in studying air, water, soil, light, and sound, as well as some elementary mechanical and electrical devices. Emphasis will be placed on the physical environment as an aid to teaching the natural sciences in the public schools and on individual research as a means of learning the processes of science.

**402 Natural History Literature**
An examination of books, periodicals, and reports on historical and present aspects of environmental quality and education. Students are involved in planning and offering the lectures, discussions, and literature reports.

**403 Environmental and Natural History Writing**
For persons who wish to improve their ability to reach and influence others by publishing in magazines and newspapers. The class produces a weekly column for a local newspaper, in addition to other types of articles. Subject matter, outlets for articles, news releases, posters, newsletters, and brochures are dealt with. A working knowledge of biology and ecology is assumed.

**404-405 Field Natural History**
Studies of Northeastern plants and animals, their biology, ecology, and their use in the environmental education programs of interpretive centers, schools, and field biology courses. Man's impact on plant and animal communities is stressed. A methods and materials course.

**407 The Teaching of Elementary School Science**
The content and methods of elementary school science and nature study, with field work and laboratory emphasis on modern and experimental curricula. Includes class observation and experimentation.

**408 Methods of Teaching Science in Secondary Schools**
Current methodology, new curricula, and materials for teaching science in secondary schools. Attention is given to the aims and goals of science instruction in relation to classroom techniques. Systematic observations in local schools. Use of video tapes.

**409 Practice in Teaching Science in Secondary Schools**
Supervised teaching practice with frequent conferences and special seminars. Multimedia forms of feedback information concerning the classroom performance will be provided to the practice teacher.

**507 The Teaching of Science**
A consideration of learning theory as applied to problems of selection and organization of subject matter, methods of teaching, and instructional innovations. Study of published research relevant to the improvement of science teaching. Course is conducted in a seminar style.

**509 Development of Curriculum in Science**
Study of new science curriculum programs, including philosophy and rationale of the programs. Observation of classes using new materials. Concentrated study of science curriculum development in the area of the individual student's interest. The course is conducted in a seminar style.

**606 Science Education Seminar**

## Other Courses Offered

**499 Informal Study in Education**
For qualified students approved by an adviser on the Education staff who is personally responsible for the study, for one of two purposes: (1) to study a problem or topic not covered in a regular course; or (2) to undertake independent tutorial or honors study in the area of the student's research interests. The program is not designed for study supplementary to a regular course to increase the content and credit allocation of the course.

**500 Special Studies**

**CSE 500 Special Problems for Graduate Students**

**594 College Teaching**
Designed for those who plan to teach in colleges and universities. Concepts and methods of teaching, organization of subject matter, motivation, learning, testing, grading, and similar problems are treated.

**600 Internship in Education**
Opportunity for apprentice or similar practical experience on the graduate level in administration, agricultural education, guidance, personnel administration, supervision, and other types of professional service in education.

See also 598 under History, Philosophy, and Sociology of Education; 599 and 699 under Home Economics Education.

# Electrical Engineering

## Theory of Systems and Networks

**4450 Bioelectric Systems**
The course deals with the application of electrical systems techniques to biological problems. Electrical activity of nerve cells; generation and propagation of nerve impulse; voltage clamp technique, Hodgkin-Huxley model, and its phase-plane analysis; electrical excitability and transfer function of neuromuscular systems; synaptic transmission; models of nerve cells and control system analysis of oscillatory activity. Nerve nets: evoked activity; spontaneous activity; simulation and computer analysis. Functional neuroanatomy of brain; transfer characteristics of sensory receptors; sensory encoding and processing in the peripheral and central nervous systems; neural mechanisms for vision and hearing.

**4453 Introduction to Biomechanics, Bioengineering, Bionics and Robots (Theoretical and Applied Mechanics 1801)**

**4475 Active and Digital Network Design**
Introduction to network synthesis in terms of immittance and scattering parameters. Design of passive filters and matching networks. Active RC filter synthesis using negative-impedance converters (NIC), gyrators, and controlled sources. State-variable synthesis techniques using operational amplifiers. Practical realizations of active RC filters and sensitivity considerations. Active 2-port network theory and design of transistor amplifiers (bipolar and FET). Negative-resistance amplifiers using tunnel diodes and varactors. Introduction to digital signal processing and discrete-time network design. Z-transform and the discrete Fourier transform (DFT). Design of nonrecursive and recursive digital filters. Realizations of digital processing algorithms by either software procedures or hardware implementations. The fast Fourier transform (FFT) algorithms. Topics for the optional laboratory session: design and construction of passive and active filters based on analytical and computer-aided techniques using available computer programs; transistor (bipolar and FET) amplifier design using measured scattering parameters; simulation and hardware implementation of digital filters; computational realizations of DFT and FET algorithms.

**4478 Computer Methods in Electrical Engineering**
Course designed to present modern techniques for solving electrical engineering problems on the digital computer. Emphasis on efficiency (minimizing operation counts) and numerical stability rather than theoretical implications. Laboratory used for experimenting with algorithms in an interactive environment. Solution of linear and nonlinear algebraic equations; finding eigenvalues and eigenvectors; rootfinding; interpolation and extrapolation; integration; solution of ordinary differential equations; random number generators. Parameter optimization. Computer hardware and software considerations in implementing algorithms. Applications to power systems, circuit design, semiconductor devices, communication systems.

**4503 Theory of Linear Systems**
The state-space model for linear systems. Properties of ordinary linear differential equations. Fundamental and transition matrices. Matrix exponential functions, the Cayley-Hamilton theorem and the Jordan form. Time-invariant and time-varying network and system response. Controllability, observability, stability. Realizability of linear causal systems and applications of Fourier, Laplace, Hilbert transforms. Paley-Wiener theorem. Distributed systems. At the level of *Introduction to Linear System Theory* by Chen.

**4504 Theory of Nonlinear Systems I**
Analysis of first- and second-order nonlinear systems with applications. Phase plane analysis of autonomous systems; singular points, limit cycles, and equilibrium states; theories of Bendixson, Lienard, and Poincare; relaxation behavior in the phase plane; perturbation theory, existence, convergence, and periodicity of perturbation series; the methods of van der Pol, and Krylov and Bogoliubov. Forced nonlinear systems harmonics, subharmonics, jump phenomena, and frequency entrainment; periodic systems, Floquet theory, Mathieu-Hill theory, applications to the stability of nonlinear systems and to parametrically excited systems.

**4507-4508 Random Processes in Electrical Systems**
The cencepts of randomness and uncertainty and their relevance to the design and analysis of electrical systems. An axiomatic characterization of random events. Probability measures, random variables, and random vectors. Distribution functions and densities. Functions of random vectors. Expectation and measures of fluctuation. Moment and probability inequalities. Properties and applications of characteristic functions. Models of convergence of sequences of random variables; laws of large numbers and central limit theorems. Kolmogorov consistency conditions for random processes. Poisson process and generalizations. Gaussian processes. Covariance stationary processes, correlation functions, spectra; Bochner and Wiener-Khinchin theorems. Continuity, integration, and differentiation of sample functions. Hilbert space approach to optimum filtering and prediction. Spectral representation, orthogonal series representations. Markov chains and processes. Linear and nonlinear transformations of random processes.

**4571 Network Analysis**
Introduction to network topology. Network formulation for computer-aided analysis. State-space techniques for time-invariant and time-varying networks. Scattering, immittance, hybrid formalisms. Nonreciprocal and active network properties. Scattering and realizability theorems for multiport networks. At the level of *Network Theory: An Introduction to Reciprocal and Non-Reciprocal Circuits* by Carlin and Giordano.

**4572 Network Synthesis**
Physical basis for network techniques in lumped and distributed systems deduced from linearity, time-invariance, and power-energy constraints. Generalized bounded real and positive-real functions and matrices and the theory of physical realizability. Applications to insertion-loss synthesis, synthesis of n-ports, design of transmission line filters, and equalizers. RC-lines. Gain band-width theory of active devices. Synthesis of active networks.

**4575 Computer Aided Network Design**
Frequency and time domain analysis of large linear circuits. State-variable and matrix techniques. D.C. and transient analysis of nonlinear circuits. Tolerancing and sensitivity calculations, adjoint network approach. General formulation of computerized design methods in time or frequency domains. Unconstrained and constrained optimization methods and computer programs. Modelling of circuits. Filter and active RC circuit synthesis methods. Methods of eliminating numerical sensitivity problems. Implementation of algorithms of cascading active and digital circuits.

## Electronics

**4412 Solid State Physics and Applications**
Introduction to solid state physics with emphasis on

application to electronic devices: crystal structure and symmetries, Brillouin zone representation of periodic structures, free-electron theory of conductivity, Drude theory of electrical conductivity, band theory; semiconductors, semiconductor devices; dielectric properties of solids, magnetism, and superconductivity. At the level of *Electronics of Solids* by Beam.

**4430 Introduction to Lasers and Optical Electronics**
Introduction to stimulated emission devices such as masers, lasers, and optical devices based on linear and nonlinear responses to coherent fields. The material discussed will be based on quantum mechanical results but will employ phenomenological theories and stress applications to modern devices. Subjects covered include: propagation of rays, spherical waves and gaussian beams; microwave and optical resonators and their field characteristics; interaction of matter and radiation; absorption and amplification; threshold for oscillation, rate equations and output power; specific laser and maser systems; harmonic generation and optical mixing; modulators; parametric converters; detectors; elements of holography. Laboratory experiments, used to illustrate and elaborate on specific lecture material, will include: atom, ion, molecular, and solid state laser oscillators and their characteristics; mode properties of coherent optical fields; harmonic generation; optical mixing; optical communications link. At the level of *Introduction to Optical Electronics* by Yariv and *Introduction to Masers and Lasers* by Seigman.

**4431, 4432 Electronic Circuit Design**
Design techniques for circuits used in electronic instrumentation. Circuits will be designed to provide specific functions, then constructed and tested in the laboratory. At the level of *Pulse Digital and Switching Waveforms* by Millman and Taub.

**4433 Semiconductor Electronics I**
Band theory of solids; properties of semiconductor materials; the physical theory of p-n junctions, metal-semiconductor contacts, and p-n junction devices; device fabrications; properties of semiconductor devices such as diodes and rectifiers, light-sensitive and light-emitting devices, field-effect and bipolar-transistors, unijunction transistors, p-n p-n devices (diodes, controlled rectifiers and switches), etc.; device equivalent-circuit models; field-effect and bipolar-transistor amplifier stages. At the level of *Semiconductor Electronics* by Ankrum.

**4434 Semiconductor Electronics II**
A continuation of 4433 with emphasis on the application of semiconductor devices as active or passive elements in circuits for use as power supplies, power controls, amplifiers, oscillators and multivibrators, pulse circuits, gates and switches, etc.; transistor noise; integrated circuits.

**4437-4438 Solid State Microwave Devices and Subsystems I and II**
A theoretical and experimental study of modern solid state microwave devices and subsystems based on the Gunn Effect diode, IMPATT diode, TRAPATT diode, tunnel diode, p-n diode, and the transistor. Initially, the basic elements of microwave systems and subsystems such as oscillators, amplifiers, modulators, and detectors are studied, and then more complex elements such as microwave network analyzers, superheterodyne receivers, spectrum analyzers, noise measuring equipment, time domain reflectometers, and experimental Doppler Radars. Typical uses of solid state devices in these subsystems are discussed and analyzed. In many cases the subsystems themselves are used to characterize the circuit parameters of microwave solid state devices and other subsystems. As part of the course, the student will have an opportunity to study and operate a wide variety of modern test equipment such as the H.P. Network Analyzer, Sampling Oscilloscopes, near-carrier oscillator noise test sets, Spectrum Analyzers, and microwave laboratory test bench equipment. He will also participate in the design and testing of varactor tuned oscillators, low noise oscillators, Doppler Radar speed measuring devices, and other devices and subsystems of interest to the class. At the level of *Microwave Semiconductor Devices and Their Applications* by Watson.

**4527 Opto-Electronic Properties of Semiconductors I**
Examination of those optical and electronic properties of semiconductors which make them useful as devices for detecting or generating optical radiation. Stress is laid on detection processes. Topics include: review of the macroscopic theory of reflection and propagation of electromagnetic waves in lossy and anisotropic media, classical and quantum-mechanical treatment of the microscopic theory of absorption in solids due to electronic transitions, including inter-and intra-band, impurity, surface state and exciton processes. The band-theory of photoemission is discussed. Physics of hot and cold carrier transport including effects of trapping, recombination and scattering are treated. Topics are mainly concerned with semiconductors, but metals and insulators are not excluded. Principles are illustrated by their application to the performance analysis of actual photoconductive, thermal, and photoemissive detectors. At the level of *Physics of Electronic Conduction in Solids* by F. J. Blatt; *Semiconductor Photoelectric Devices* by A. Ambroziak; *Solid State Theory* by W. A. Harrison; and the current literature.

**4528 Opto-Electronic Properties of Semiconductor II**
A continuation of Opto-Electronic Properties of Semiconductors I with stress given to generation processes. Continued treatment of carrier transport and scattering effects, recombination of carriers at imperfections, surfaces, and through exciton processes. Carrier transport via tunneling in metal-insulator-semiconductor structures, double-injection in insulators; theory of internal photoemission and interface barriers, theory of semiconductor lasers, effects of geometry on photoemissive devices. At the level of *Tunneling in Solids* by C. B. Duke; *Quantum Electronics* by A. Yariv; *Semiconductors and Semimetals,* Vol. 2, by Williamson and Beer; and current literature.

**4531 Quantum Electronics I**
A detailed treatment of the physical principles underlying optical masers, related fields, and applications. Topics will include: a review of quantum mechanics and the quantum theory of angular momentum; the interaction of radiation and matter; the quantum mechanical density matrix and macroscopic material properties; theory of the laser and maser. At the level of *Quantum Electronics* by Yariv and *Fundamentals of Quantum Electronics* by Pantell and Puthoff.

**4532 Quantum Electronics II**
A continuation of the treatment of the physical principles underlying optical masers and related fields. Topics will include: optical resonators; output power of amplifiers and oscillators; dispersive effects and laser oscillation spectrum; Lamb theory; spectroscopy of atoms, molecules and ions in crystals as examples of laser media; survey of chemical and dye lasers; noise in optical devices; principles of electrooptic and parametric devices.

**4534 Nonlinear and Quantum Optics**
A detailed study of recent developments in the theory

and application of nonlinear and coherent optics. Topics will include the use of density matrix and quantum field theory in nonlinear optics and the theory of coherence; spontaneous and stimulated Brillouin, parametric, and Raman processes; optical subharmonic and harmonic generation; optical mixing; frequency down- and up-conversion processes, optical parametric oscillator and other nonlinear optical devices. At the level of current published literature on these topics.

**4535 Solid State Devices I**
A study of the properties of semiconductor devices with emphasis on low-frequency operation (below 1000 GHz). Devices based on the tunnel effect: tunnel diodes, zener diodes, field emitter cathodes, thin film resistors. Devices based on charge flow across semiconductor-semiconductor contacts: p-n diodes, avalanche diodes, transistors, field effect transistors, unipolar transistors. Devices based on metal semiconductor contacts: Schottky triode. Emphasis is placed on determining the factors underlying performance capabilities. Equivalent circuits are developed. The student will either carry out a term laboratory project or prepare a term paper on an appropriate contemporary topic. The course is presented at the level of *Physics of Semiconductors* by Moll and of current papers published in the *IEEE Transactions on Electron Devices.*

**4536 Solid State Devices II**
A study of the properties of semiconductor devices with emphasis on high frequency operation (above 1000 GHz). The approaches to the analysis to be studied are: ballistic analysis, electronic-network analysis, space-charge wave and coupled-mode analysis. Devices studied include avalanche microwave diode (Read diode), Gunn oscillators, fast response photodiodes, and other contemporary devices. Emphasis is placed on determining the factors that underlie the performance capabilities. Equivalent circuits are developed. The student will either carry out a term laboratory project or prepare a term paper on an appropriate contemporary topic. The course is presented at the level of current papers published in the *IEEE Transactions on Electron Devices.*

**4537 Integrated Circuit Techniques**
Integrated circuit techniques applicable in the fields of computer, telecommunication, and opto-electronics are covered. The emphasis is on the device technology and the device system interface. Computer logic and memory circuits with special interest in monolithic MOS structures are discussed. Telecommunication applications concentrate on microwave hybrid integration of avalanche diode and Gunn and LSA oscillators in transmitters and receivers. In optoelectronics, solid state sensor and display panels are treated, particularly incorporating III-V and II-VI compound semiconductor devices. Each student has a term project. Relevant current publications are studied.

**4631 Physics of Solid State Devices**
The phenomena and problems associated with conduction in high electric fields will be considered; the emphasis will be mainly on semiconductors. A review will be given of hot electron phenomena, especially where instabilities arise because of multivalley band structure of other interaction of charge carriers with the host crystal. Basic theory of electron and hole scattering by phonons will be covered and methods of obtaining distribution functions from the Boltzmann equation will be examined. In addition, modifications required by complications of band structure will be discussed.

**4632 Physics of Solid State Devices**
The analysis of solid state devices of current interest (avalanche, LSA, Gunn devices, etc.) will be considered in sufficient detail to give an understanding of some of the limitations involved in the design of such devices. Particular scattering mechanisms and band structure complications will be considered in obtaining realistic distribution functions. Emphasis will be on analytical solutions because of the physical insight they afford, but numerical methods will also be considered. The number of devices considered will be limited, but subjects of specific interest to individuals can be considered on a seminar basis.

## Power Systems and Machinery

**4441 Contemporary Electrical Machinery I**
Emphasis on engineering principles. Real and reactive power requirements of core materials with symmetrical and with biased magnetizing forces; analysis and characteristic prediction of high-efficiency transformers; magnetic amplifiers, energy transfers among electric circuits, magnetic fields, and mechanical systems; control of magnetic field distribution by reluctance and winding distribution; traveling fields from polyphase excitation; elementary idealized commutator-type, asynchronous, and synchronous machines.

**4442 Contemporary Electrical Machinery II**
Emphasis on engineering principles. Production of air-gap magnetic fields; elementary and idealized rotating machines; steady state and transient characteristics of realistic rotating machines; a-c commutator-type single-phase motors; polyphase synchronous and single-phase induction machines; recently developed types; Saturistor motor, self-excited a-c generators; miscellaneous rotary devices; hysteresis motor, selsyns, amplidynes, frequency converters.

**4443 Power System Equipment**
Engineering responsibilities for system equpiment and control are studied. Emphasis is placed on producer-user relations for catalog or built-to-order items. Calculations and test requirements of electrical apparatus for electrical power production, distribution, and use are considered. Prime movers, generators and their accessories, switchgear, protective devices, power transformers, converters, towers, conductors, and regulating devices are analyzed. Inspections of nearby plants and equipment supplement classroom work.

**4444 High-Voltage Phenomena**
The study of problems of the normal operations of power apparatus at very high voltages. The abnormal conditions imposed by lightning and the methods employed to assure proper operation are considered. Laboratory testing of equipment under actual or simulated conditions, being an essential step in the engineering design of high-voltage apparatus, is given particular attention. Considerable attention is given to dielectric behavior, traveling wave, and dielectric testing techniques. Electrical manufacturing test facilities are visited.

**4445 Electric Energy Systems I**
The physical and engineering principles underlying steady state operation and control of modern electric power systems, with emphasis on the characteristics of major power-system parameters. Theory of electromechanical energy converters, power transformers, conventional transmission lines and cables, power networks, and other power-system components; use of the digital computer as a dynamic "laboratory" model of a complex power system for load-flow studies. Laboratory-computing periods will include selected experiments with small electromechanical energy converters. At the level of *Elements of Power System Analysis* (2nd ed.) by Stevenson.

**4446 Electric Energy Systems II**
Continuation of principles presented in Electric Energy Systems I with emphasis on transient behavior of power networks. Theory of unbalanced systems, symmetrical components, protective relaying systems, power-system stability, high-voltage–direct-current systems and economic dispatch; use of the digital computer for fault studies and economic analysis. At the level of *Elements of Power System Analysis* (2nd ed.) by Stevenson.

## Radio and Plasma Physics, Electromagnetic Theory

**4461 Wave Phenomena in the Atmosphere**
An elementary treatment of wave phenomena in the atmosphere of the earth, including gravity waves, planetary waves, acoustic waves, radio waves, and plasma waves; attention is directed to the role of these phenomena in various atmospheric processes and engineering problems such as weather, pollution, radio communication, atomic fall-out.

**4462 Radio Engineering**
A study of electrical systems for communications, control, detection, and other purposes in which radiowaves play a central role: system functions, including generation, modulation, transmission, reception, and demodulation; guidance, radiation, and propagation of radiowaves, including transmission lines and waveguides, antenna systems, and the effects of atmospheric inhomogeneity; system design problems.

**4464 Elementary Plasma Physics and Gas Discharges**
Review of electromagnetic wave theory and applications. Gas discharges and arcs: positive column, collisions, mobility, diffusion, breakdown, sheaths, DC and RF excitation, transition from glow to arc, Langmuir and conductance probes, reflex discharge, effects of magnetic field. Plasma as a dielectric medium, interaction of electromagnetic waves (e.g., microwaves) with plasma in free space and finite regions. Plasma oscillations, space-charge waves, cyclotron harmonic radiation, Tonks-Dattner resonances, effects of plasma temperature. At the level of *Plasma Diagnostics with Microwaves* by Heald and Wharton.

**4511 Electrodynamics**
Foundations of electromagnetic theory. Maxwell's equations, electromagnetic potentials, and integral representations of the electromagnetic field. Special theory of relativity. Radiation of accelerated charges and Cerenkov radiation. Electrodynamics of dispersive and anisotropic media. Normal modes of waveguides and cavities. Surface waves and leaky waves. At the level of *Theory of Electromagnetism* by Jones.

**4514 Microwave Theory**
Theory of passive microwave devices. Waves in homogeneous and inhomogeneous waveguides; propagation and distortion of pulses; application of gyrotropic media to nonreciprocal waveguide devices. Scattering matrix analysis of multiport junctions, resonant cavities, directional couplers, isolators, circulators. Periodic waveguides. Elastic waves in solids and their microwave applications. At the level of *Introduction to the Theory of Microwave Circuits* by Kurokawa.

**4551-4552 Upper Atmosphere Physics I and II**
The physical processes governing the behavior of the earth's ionosphere and magnetosphere. Topics will include diagnostic measurement techniques; production, loss, and transport of charged particles in the ionosphere and magnetosphere; temperature variations; airglow; tidal motions, winds, and gravity waves in the ionosphere; the electrical conductivity of the ionosphere, the dynamo current system, and the equatorial and auroral electrojets; plasma instabilities in the ionosphere; interactions between the ionosphere, magnetosphere, and solar wind; acceleration and drift of energetic particles in the magnetosphere; precipitation of particles and the aurora; magnetic and ionospheric storms. At the level of *Introduction to Ionospheric Physics* by Rishbeth and Garriott.

**4561 Introduction to Plasma Physics**
Plasma state; motion of charged particles in fields; adiabatic invariants, collisions, coulomb scattering; Langevin equation; transport coefficients, ambipolar diffusion, plasma oscillations and waves; hydromagnetic equations; plasma confinement, energy principles, and microscopic instabilities; test particle in a plasma; elementary applications. At the level of *Elementary Plasma Physics* by Longmire.

**4564 Advanced Plasma Physics**
Boltzmann and Vlasov equations; moments of kinetic equation, Chew-Goldberger-Low theory, waves in hot plasmas, Landau damping, instabilities due to anisotropies in velocity space, gradients in magnetic field, temperature and density, effects of collisions and Fokker-Planck terms; high-frequency conductivity and fluctuations, quasi-linear theory; nonlinear wave interaction, weak turbulence and turbulent diffusion.

**4565 Radiowave Propagation I**
Propagation in the earth's environment: the troposphere, ionosphere, magnetosphere, and interplanetary space. Diffraction and surface wave propagation; tropospheric refraction and ducting; propagation in the ionospheric plasma, including magnetoionic theory, the CMA diagram, cross modulation and Faraday rotation, whistler mode propagation, ion effects and ion whistlers, group velocity and ray tracing. WKB solutions of the coupled wave equations.

**4566 Radiowave Propagation II**
Full wave solutions of the coupled wave equations; interactions between particles and waves in the magnetosphere; radar astronomy; the scattering of radio waves from random fluctuations in refractive index; tropospheric and D region ionospheric scatter propagation; incoherent scatter from the ionosphere and its use as a diagnostic tool; radio star and satellite scintillations and their use in studying the ionosphere and solar wind.

**4567 Antennas and Radiation**
Formulation of the electromagnetic field in terms of vector and scalar potentials; radiation from elemental electric and magnetic dipoles. Linear radiators; radiation from short dipoles, small loops; resonant wire antennas; long wire antennas, linear arrays, and pattern synthesis; impedance properties of wire antennas, including mutual impedance, parasitic elements; wire receiving antennas. Aperture antennas: uniqueness theorem for vector fields, equivalence and induction principles; radiation from open-ended waveguides, horn antennas, reflector antennas; Babinet's principle; slot antennas. Laboratory experiments will be conducted on an antenna range. At the level of *Electromagnetic Waves and Radiating Systems* by Jordan.

**4661 Kinetic Equations**
Designed for students wishing a firm foundation in fluid dynamics, plasma-kinetic theory, and nonequilibrium statistical mechanics. Brief review of classic dynamics. The concept of the ensemble and the theory of the Liouville equation. Prigogine and Bogoliubov analysis of the BBKGY sequence. Chapman-Kolmogorov analysis of Markovian kinetic equations. Derivation of fluid dy-

namics. Kinetic formulation of the stress tensor. Boltzmann, Krook, Fokker-Planck, Landau, and Balescu-Lenard equations. Properties and theory of the linear Boltzmann collision operator. Chapman-Enskog and Grad methods of solution of the Boltzmann equation. Klimontovich formulation. Coarse graining and ergodic theory. At the level of *Introduction to the Theory of Kinetic Equations* by Liboff.

## Communications, Information, and Decision Theory

**4467 Statistical Aspects of Communication**
Analysis of analog and digital communication systems in the presence of random signals and noise. System optimization, matched filters, linear smoothing, and prediction of stationary processes. Modulation systems, performance of analog systems in time and frequency multiplex with additive noise; digital modulation systems, PCM systems with additive noise. Design of signals for digital transmission. Receiver optimization, design of decision-oriented receivers, error bounds; selected topics in hypothesis testing and parameter estimation applied to receiver design.

**4473 Coding Algorithms**
Coding algorithms for compression and storage of information, for correction of errors in digital data processing and transmission, and for synchronization. Design, analysis, and implementation of underlying codes. Linear block codes, convolutional codes, maximum likelihood and sequential decoding, linear sequential machines, cyclic codes, Bose-Chaudhuri codes, burst error protection, threshold decoding, variable length source coding. Laboratory consists of demonstrations and projects involving design and computer simulation, modification, and evaluation of coding algorithms covered in lecture. At the level of *An Introduction to Error Correcting Codes* by Lin.

**4474 Fundamental Information Theory**
Fundamental results of information theory and their application to information storage, compression, processing, and transmission. The basis of modern design of digital communication systems. Source coding, properties of entropy, and other information measures. Signal selection and detection aspects of noisy transmission channels. Channel capacity and Shannon's coding theorems. Analysis of sequential decoding. Fidelity criteria and rate-distortion functions. Communication over Gaussian channels. Laboratory projects investigate through computer simulation the statistical problems involved with information source and channel characterization and approximation (quantization), and evaluate the advantages and limitations of the various coding algorithms introduced in 4473. At the level of *Information Theory* by Ash.

**4672 Foundations of Inference and Decision Making**
Much advanced research in information processing and its applications involves sources about which we have very little knowledge and the use of performance criteria of doubtful adequacy. These difficulties motivate an examination of methods for characterizing uncertainty and chance phenomena and for transforming information into decisions and optimal systems. The discussion of the foundations of inference centers on various approaches to the interpretation and formalization of probability, including the following: axiomatic systems of comparative probability; Kolmogorov system of quantitative probability; relative frequency interpretations; computational complexity, randomness, and probability; classical probability and invariance; logical probability and induction; subjective probability and personal decision making. The discussion of the foundations of decision making will center on utility theory, axiomatic rationality, statistical decision theory, the nature of a good system, and recent work on system design when there is little prior information.

**4673 Principles of Analog and Digital Communication**
The fundamentals of information theory, signal theory, and statistical estimation and decision theory are used to formulate approaches to the solution of problems arising in digital and analog communication. Particular topics are: receiver and signal design, probability of error, capacity, threshold effects for the additive Gaussian channel. Extensions to the additive Gaussian channel: feedback, random gain and phase, diversity. Time-variant Gaussian channels; receiver and signal design, probability of error, and capacity. At the level of *Principles of Coherent Communication* by Viterbi.

**4674 Transmission of Information**
An in-depth treatment of an information theory research area. The topic varies from year to year and will be chosen from the following subjects: Source encoding (rate distortion theory), convolutional codes and sequential decoding, information nets, ergodic theory and information in abstract spaces, and complexity and instrumentability of coding schemes.

**4676 Decision and Estimation Theory for Signal Processing**
An examination of selected decision or estimation problems encountered in the design and analysis of radar/sonar target discrimination, signal-demodulation, and pattern-classification systems. The hypotheses of risk and uncertainty, the role of objectives, criteria for evaluating decision or estimation procedures, and characteristics of such procedures. Additional topics, drawn from the fields of parametric and nonparametric statistics, empirical time-series analysis, and nonprobabilistic decision or estimation procedures, will be treated as required for the resolution of the selected problems.

## Computing Systems and Control

**4481-4482 Feedback Control Systems**
The analysis of feedback control systems, and synthesis techniques to meet specifications or minimize performance indices. Mathematical models of physical systems and solution of differential equations by the Laplace transform; transfer functions. The state-space approach to control systems; observability, controlability. Analysis and synthesis of linear control systems by root locus and frequency response methods. Nonlinearities in control systems; analysis and compensation using describing functions and the phase-plane; Lyapunov stability. Sampled-data systems and digital compensation. An introduction to parameter optimization and optimal control. Laboratory work consists of familiarization with system components and correlation of transient and frequency responses; synthesis of linear and optimal control systems, and analysis of nonlinear and sampled-data systems using analog and digital computers.

**4483 Analog Computation**
Concepts and principles of analog computation and simulation as applied to engineering analysis and design. Linear, time-varying, and nonlinear differential equations. Automatic iterative and basic optimization techniques using digital logic. Laboratory work with general-purpose analog computers. At the level of *Methods of Solving Engineering Problems Using Analog Computers* by Levine.

**4484 Analog-Hybrid Computation**
Theory, design, characteristics, and programming of analog-oriented hybrid computer systems; analog-digital computer linkage systems; error analysis and error compensation in hybrid computation; theory and laboratory work on automatic iterative procedures, steepest-descent programs, parameter optimization and parameter identification methods. The laboratory will make use of an analog computer linked with digital logic components. At the level of *Hybrid Computation* by Bekey and Karplus.

**4487 Switching Circuits and Logic Design**
Switching devices, Boolean algebra; function minimization and decomposition; adders and other combinational circuits; number representation and codes; synchronous and asynchronous sequential circuits; circuit equivalence; secondary assignments; counters and shift registers; fault detection and diagnosis. Topics for the optional laboratory session: design and construction with MSI modules of counters, shift registers, adders and other arithmetic circuits in digital computers. At the level of *Switching Circuits: Theory and Logic Design* by Torng.

**4488 Structures of Computing Systems**
Architecture and design of computing systems; configuration of components; memory organization; central processing unit design; input-output management, channel controller; program interrupt and service interrupt; fault detection and diagnosis; systems in time-sharing environment. Topics for the optional laboratory session: design and implementation of small scale general purpose or special purpose calculators and computers.

**4505 Estimation and Control in Discrete Linear Systems**
Optimal control, filtering and prediction for discrete time linear systems with extensive use of the APL/360 system. Approximation on discrete point sets, curve fitting with various error measures. Modelling of discrete time systems with applications to tracking and estimation problems. Optimal control of discrete time linear systems, the principle of optimality. Optimal filtering and prediction for discrete time linear systems, Kalman filtering. Stochastic optimal control, the separation principle. No knowledge of a programming language is assumed; the APL language will be learned during the term through use of a library of programs written for the course. At the level of *Stochastic Optimal Linear Estimation and Control* by Meditch.

**4506 Optimal Control and Estimation for Continuous Systems**
Methods of design problem formulation, computational techniques, and mathematical background are developed for the implementation of continuous optimal control and estimation. Deterministic and stochastic controls as well as unbiased estimators are formulated on both finite and infinite time intervals. Extensive examples are given such as re-entry vehicle flight-control, rocket-booster guidance, aircraft tracking, and substitution are presented for minimization with respect to parameters and functions, with and without equality and inequality constraints. Properties of Lyapunov and Riccati equations are discussed. Material is illustrated by student use of an APL library of computer programs for the automated design of continuous controls and estimators.

**4580 Machine Organization**
Design and analysis of computer systems from the viewpoint of systems engineers. Both conventional and unconventional computer systems will be treated. Emphasis will be on the modelling and evaluation of large computer systems. Topics will include machine modules, states of modules and the concepts of interrupts, storage allocation, processor allocation, statistical and algebraic models for computer systems and information processing systems, simulation languages, simulation models and system evaluation, teleprocessing systems, failure-tolerant computer systems, and parallel processing systems.

**4591-4592 Project**
Individual study, analysis, and, usually, experimental tests in connection with a special engineering problem chosen by the student after consultation with the faculty member directing his project; an engineering report on the project is required.

**4595-4596 Electrical Engineering Design**
For students enrolled in the M.Eng. (Electrical) program. Utilizes real engineering situations in which to present fundamentals of engineering design.

**4681 Random Processes in Control Systems**
Prediction and filtering in control systems; Gaussian-Markov sequence, Gaussian-Markov process, prediction problem, generalized Wiener filtering, stochastic optimal and adaptive control problems. Selected topics: Bayes decision rule, min-max policy, maximum likelihood estimate, control of systems with uncertain statistical parameters; stochastic differential equations, optimal nonlinear filtering; stability of control systems with random parameters.

**4691-4692 Electrical Engineering Colloquium**
For graduate students enrolled in the Field. Lectures by visiting authorities, staff, and graduate students. A weekly meeting for the presentation and discussion of important current topics in the field.

**4700, 4800 Special Topics in Electrical Engineering**
Seminar, reading course, or other special arrangement agreed upon between the students and faculty members concerned.

# English Language and Literature

**500 Critical and Scholarly Perspectives**
An inductive approach to the important problems in the scholarly investigation and critical discussion of literature, as these emerge in a close study of a single masterpiece in English literature. Beginning Ph.D. students are urged to enroll.

**501 Readings in Old English**
Elements of Old English grammar and reading in the shorter literary texts.

**502 Beowulf**
A reading of the poem in Old English and discussion of the literary and historical problems which it presents.

**503 Middle English**
Reading and critical analysis of major works, excluding Chaucer and the drama.

**504 Chaucer**
Reading and critical analysis, with emphasis on *Troilus* and *Canterbury Tales.*

**508 The English Language**
A study of major problems in the history and development of language from the Old English period to the present time. Though the course will be based on a historical survey, students will be given freedom to work in areas of particular interest, whether ancient or modern. Some knowledge of Old English is very strongly advised.

**510 Grammatical Analysis**
Study of the structures of English revealed in the transformation of the basic components of predications.

**512 Medieval Drama**
Dramatic forms and traditions from the liturgical drama to the Elizabethan period.

**513 Elizabethan and Jacobean Drama**
Studies in the dramatic works of Shakespeare's contemporaries and immediate predecessors.

**518 Studies in Elizabethan Literature**
Particular emphasis upon the shorter forms of Elizabethan verse, with some consideration of Continental influences.

**520 Readings in Seventeenth-Century Literature**
The work of Ben Jonson—his plays, his poems, his criticism.

**521 Milton**
Milton's English poems and selected prose.

**523 Studies in Dramatic Form: Tragedy**
A study of major theories of tragedy and their application to specific dramatic texts. Special attention will be paid in class to Aristotle, Hegel, and Nietzsche, and to Greek and Shakespearean tragedies.

**527 Eighteenth-Century Literature**
Readings in Pope and his contemporaries, with attention to relationships between literature and the fine arts.

**530 The New England Mind, 1620–1860**
The major texts of Puritanism studied in relation to the literary productions of Emerson, Hawthorne, and Melville. The emphasis will be on varieties of Puritan inheritance.

**531 Studies in American Literature: Melville and Hawthorne**
Discussion of major works.

**533 The Intellectual Origins and Development of the Romantic Movement in America**
The intellectual and social context and genesis of American romanticism, with particular emphasis on the theme of antirationalism.

**535 The Intellectual Origins of the Modern Consciousness in American Literature and Thought**

**537 Studies in American Literature: Naturalism**
"Nature" in American literature before and after Darwin and Spencer. A comparative study, with emphasis on representative works by Melville and Dreiser.

**549-550 Creative Writing**

**554 Studies in English Poetry**
Imagery and organization in a variety of narrative, descriptive, and lyric poems, from Spenser to Wallace Stevens.

**561 Studies in Shakespeare**
A study of Shakespeare which examines various twentieth-century critical approaches and pays particular attention to *The Rape of Lucrece, The Merchant of Venice, Hamlet, King Lear,* and *The Winter's Tale.*

**564 Dramatic Literature: Shaw and O'Neill**
A detailed study of the plays of Bernard Shaw and Eugene O'Neill and of their backgrounds.

**567 Dramatic Criticism**
A study of the principal modes and problems of dramatic criticism. The work will consist of studying plays as well as critics, and of testing and evaluating as well as describing established lines of critical inquiry.

**568 The Eighteenth Century**
A discussion course based on extensive reading in the works of Jonathan Swift, Alexander Pope, or Samuel Johnson.

**571 Studies in Romanticism**
Milton and the Romantics. Exploration of the romantic response to the literary past embodied in Milton. Emphasis on the major creative work of Blake, Wordsworth, Shelley, and Keats, with some attention also to critical writings of the period. Consideration of the nature of literary tradition and of poetic influence.

**575 Victorian Prose**
An introductory graduate course on major works in Victorian nonfictional prose, with some attention to the novel. Chief writers studied include Carlyle, Mill, Arnold, Ruskin, Newman, Dickens, Thackeray, and George Eliot.

**576 Victorian Poetry**
An introductory graduate course in the Victorian poets, with some study of two novelists who were also poets. Major emphasis on Tennyson, Browning, and Arnold, but with some attention (as time permits) to Rossetti, Swinburne, Morris, Meredith, Hardy, and Hopkins.

**583 Boston and American Literature**
A review of some of the principal works expressive of Boston culture from the mid-nineteenth century to the present, using Martin Green's *The Problem of Boston* as starting point. Research on historical, literary, or cultural topics of individual interest will be encouraged.

**584 Forms of the Novel**
Gothic Romance in eighteenth-, nineteenth-, and twentieth-century manifestations.

**588 Voice and Tone**
An examination of alterations in voice and tone in nineteenth- and twentieth-century fiction. Novels selected from the work of such writers as Eliot, Trollope, Forster, and Pyncheon.

**592 Twentieth-Century Literature**
The later works of James Joyce, specifically *Ulysses* and *Finnegans Wake.* Knowledge of *Dubliners* and *A Portrait* will be assumed.

**594 Studies in Twentieth-Century American Literature**
An examination of the work of two or three representative poets of the twentieth century (such as Frost, Stevens, or Williams) and two or three representative writers of fiction (such as Faulkner, Fitzgerald, or Hemingway).

**597 Literary Criticism**
An introductory course intended for those who have had little or no *formal* study of criticism. The course will consider three general modes of theoretical criticism prominent within the English critical tradition: (1) mimetic, plot criticism: Aristotle and later Aristotelians; (2) audience-oriented, rhetorical criticism: Horace to Kenneth Burke; (3) "objective" or contextual criticism: The New Critics and their influence. Some attention will be given to historical development.

**598 Master's Essay**

**599 Practice Teaching**
For M.A.T. candidates in English. Students should enroll concurrently in English 488.

**600 Directed Study**
A course, usually but not necessarily taken early in the student's graduate career, in which under the supervision of a professor he reads works which relate to his individual program of study. *Or,* a course in which under the supervision of a professor the student explores areas in which no appropriate seminars are offered. The subject matter may consist of a problem formulated by the student (perhaps culminating in a

paper), or of background material relevant to the student's major interests, or both.

**601 Group Study**
A course formulated by students in which they meet to consider problems or areas of mutual interest, under the sponsorship of one or more professors.

**602 Advanced Old English**
Studies in Old English Christian poetry.

**608 Studies in Medieval Literature**
Advanced research in English (and other) medieval literature.

**616 Studies in the Sixteenth Century: Sir Philip Sidney**
An examination of the literary achievement of Sidney, as poet and writer of fiction, with particular reference to the two versions of the *Arcadia* and the theories embodied in *The Defence of Poesie.*

**617 Studies in the Seventeenth Century: John Donne**
An intensive examination of the scholarly and critical work pertinent to an understanding of Donne and of the late Renaissance.

**672 Wordsworth**
Critical and textual studies based upon the Dove Cottage manuscript archive.

**675 Romantic Poetry and Romantic Criticism**
Coleridge's *Biographia Literaria,* in the context of the major works Coleridge discusses, especially the poetry and criticism of Wordsworth.

**678 Dickens**
A study of the major novels. The seminar will stress Dickens' aesthetics and politics within the larger framework of Victorian thought. Some attention will be paid to Dickens' nonfictional works.

**684 Studies in American Fiction**
The novels of William Faulkner.

**698 Teaching and Research**
A course which combines participation (including some teaching) in a professor's undergraduate course with reading supervised by the same professor.

# Entomology

**210 Introductory Entomology**

**212 Insect Biology**

**518 Techniques of Biological Literature**

**521 Acarology**
An introduction to the taxonomy, morphology, and bionomics of mites and ticks, with emphasis on taxa of economic importance. A collection will be required.

**Research**
See members of Field for schedule and course number.

**Seminar**
Jugatae, an entomological club, meets to discuss results of investigations by its members.

## Apiculture

**262 Biology of the Honey Bee**

**562-563 Special Topics in Beekeeping**
A technical course for advanced students covering all phases of the subject. Special attention is given to improved methods of apiary and honeyhouse management and the preparation of honey for market. Current literature on beekeeping is assigned, reviewed, and evaluated by students. Lectures and discussions are supplemented by field trips.

## Ecology and Limnology

**471 Bionomics of Freshwater Invertebrates**
A field and laboratory study focused on the aquatic insects but also including the Crustacea, Mollusca, and other macroscopic invertebrates. It includes identification of these organisms, understanding where and how they live, and consideration of physical and chemical conditions and ecological relationships in different freshwater biotopes.

**577 Biological Control**
Participants will critically review theory and method of biological control of pest species.

**595 Environmental Biology**
Consideration will be given to current environmental problems, with particular emphasis on the "systems approach" to population management.

**660 Insect Ecology**
A field course stressing the methods for study of insect populations and communities. The class will engage in a coordinated set of projects during a camping trip in Florida.

**662 Insect Behavior Seminar**

**672 Seminar in Aquatic Ecology**
Discussions and analysis of current concepts and problems in limnology and aquatic entomology, with critical study of selected reference works and research papers.

## Economic Entomology

**441 Principles of Economic Entomology**
Principles in the management and control of insect populations. Collection of economic species of insects will be required.

**442 Pesticide Technology**

**541 Experimental Methods in Economic Entomology**
An advanced course dealing with the principles and methods of insect control and experimentation. Emphasis will be placed on the use of and instrumentation for work in modern methods of insect control, biology, and applied ecology. Field plot designs, field techniques, analysis of data, practical sampling methods, regulations concerning pesticide residues on field crops and in milk and meat, and effects of pesticides on pollinators will be stressed. Soil insects, small grain insects, and forage insects will be used largely as examples.

## Morphology

**322 Insect Morphology**

## Parasitology

**351 Introductory Parasitology**

**551 Advanced Parasitology (Protozoa and Helminths)**

**552 Advanced Parasitology (Medical Entomology)**
A continuation of 351 for graduate students interested in medical or veterinary entomology. Practical experience with methods of collection and preparation; detailed studies on recognition, life cycles, and control. Special emphasis is given to causative agents, vectors, and intermediate hosts of disease-producing organisms. The study examples include species of world-wide distribution, especially those of the tropical areas.

**553 Advanced Parasitology (Insect Pathology)**
A survey of the microbial and zooparasitic diseases of insects with emphasis on the natural history of the pathogens. Pathogens considered include viruses, rickettsiae, bacteria, spirochetes, fungi, protozoa, nematodes, and selected arthropods. The role of these pathogens in natural and applied insect control will also be considered.

**583 Insect Physiology, Lectures**
An introductory course in the physiology of insects. Primarily for graduate students in entomology, or physiology majors.

**584 Insect Physiology, Laboratory**
Should be taken in conjunction with 583.

## Taxonomy

**331 Introductory Insect Taxonomy**

**531 Taxonomy of the Smaller Orders of Insects**
Lectures on the classification, evolution, and bionomics of the orders and families of insects, exclusive of the larger orders of Holometabola. Laboratory studies on the literature and on the characters and classification of representative genera and species. For continuation of taxonomy of Holometabola, see 532, 533, and 534.

**532 Taxonomy of the Immature Stages of Holometabola**

**533 Taxonomy of the Coleoptera and Lepidoptera**

**534 Taxonomy of the Diptera and Hymenoptera**

## Toxicology and Insecticidal Chemistry

**590 Insect Toxicology and Insecticidal Chemistry**
The chemistry of insecticides and their metabolism and mode of action in insects and mammals.

**591 Analysis of Pesticide Residues**
Analytical techniques in extraction, isolation, and determination of pesticide residues.

**592 Introductory Insecticide Chemistry**
A brief consideration of selected physical and chemical concepts of importance in insecticidal chemistry and biochemistry.

# Floriculture and Ornamental Horticulture

The Department of Floriculture and Ornamental Horticulture does not offer courses for graduate students only; however, graduate students may take selected undergraduate courses in the Department. These courses are listed in the *Announcement of the College of Agriculture and Life Sciences*. Students should also consult the graduate course listings in this *Announcement* for Agricultural Economics, Agricultural Engineering, Agronomy, Biochemistry, Botany, Entomology and Limnology, Plant Breeding and Biometry, and Plant Pathology.

# Food Science and Technology

**200 Food Chemistry I**
This course deals with the basic chemical properties and the reactions of the constituents of food. It includes discussion of proteins, lipids, carbohydrates, vitamins, minerals, and pigments and explains how these compounds affect both the edible and nutritional qualities of foods.

**210 Food Analysis**
This course is designed to acquaint the student with a variety of chemical and bacteriological tests used by food analysts.

**300 Physical Chemistry of Foods I**
The application of physiochemical principles to the understanding of complex behavior of food systems and biological materials. Study of the principles involved in the behavior of emulsions and colloidal suspensions. The properties of solutions, reaction rates, electrolytic dissociations, hydrogen ion concentration, oxidation reduction potential, photochemistry, and introduction to energy relationships.

**301 Nutritional Aspects of Raw and Processed Foods**
The purpose of this course is to acquaint students with the nutritional problems related to food processing and the evaluation of processed food. The course will deal with the advantages and disadvantages of food processing with the ultimate aim of instilling an appreciation of food technological and agricultural advances and how these changes have influenced and can influence the nutritional well-being of mankind.

**302 Introduction to Food Engineering**
Engineering aspects of dairy and food plant operations.

**304 Sanitary Principles, Toxicology, and Public Health**
Biological and chemical control of food contamination and processing. Public Health, USDA, FDA, and other requirements for production, protection, and processing of foods. Quality assurance in foods.

**400 Research**
Special problems in any phase of food science may be elected.

**402 Concepts of Product Development**
A discussion of the sequence of events involved in the development and marketing of food products. Topics will include packaging and labeling, legal and functional ingredient restrictions, taste panels and in-store testing, patents, and pricing.

**402A Product Development Laboratory**
A laboratory to be taken concurrently with 402 lectures. Emphasis will be on gaining practical experience in the formulation and processing of new foods.

**403 International Food Development**
A study of programs, technical problems, and progress associated with developing, processing, and marketing acceptable foods throughout the world. Attention will be given to expanding protein resources for man in critical areas. International aspects of pollution and public health related to food are considered. Special attention is given to the organization, operations, relationships, and contributions of UN technical agencies, FAO, UNICEF, WHO, and governmental and nongovernmental organizations in the field.

**404 Food Processing I: Drying, Freezing, Heat Preservation**
Deals with the principles and practices of drying, freezing, canning, and other heat treatments applied to foods. Current processing methods will be considered as related to the chemistry, microbiology, and technology of the ingredients and final products.

**405 Food Processing II: Concentrating, Separating, Mixing**
Deals with the principles and practices of evaporation, reverse osmosis, filtration, centrifugation, homogenization, mixing, size reduction, and other unit operations important in the food industry.

**406 Food Processing III: Fermentations**
Principles and processes leading to important foods such as fermented milks, yogurt, cheese, wines, and beers. Consideration is also given to other fermentations resulting in foods from plants and animal sources. Demonstrations and field trips are designed to acquaint students with fermentation and enology principles, and with the physical and sensory qualities of the above foods.

**407 Food Processing IV: Fats and Oils**
The sources, composition, and properties of edible fats and oils are discussed. All classes of lipids are considered and their effects on food quality and storage stability are described. Factors affecting the chemical and physical stability of food fats are enumerated. The chemical technology of shortenings, edible oils, margarine, and butter is described.

**410A Food Chemistry II**
Deals with the effect of chemical composition on the properties of foods. Special attention will be given to the factors affecting variations in composition and the consequent changes in flavor, color, and texture.

**410B Sensory and Objective Evaluations of Foods**
Deals with sensory techniques used to evaluate the flavor, color, and texture of foods and the effect of these properties on consumer acceptance. Objective methods for measuring these qualities will be discussed and demonstrated.

**411 Food Mycology**
Intended to acquaint students with those groups of fungi that are important, from the standpoint of both their beneficial and their harmful effects, in food production, preservation, and spoilage; and to give the student some appreciation of the use of fungi as food.

**412 Aquatic Microbiology**
A consideration of the relation of microorganisms, especially the bacteria, to aquatic environments, both natural and artificial. The microbiology of waste waters will be included. Attention will be given to fundamental biological concepts and to applied aspects of the occurrence and activities of microorganisms in waters.

**499 Food Industry Management Topics**
A summary of concepts and techniques useful to Food Science majors in the areas of communication and interpersonal relationships in business. Deals primarily with oral, written, and visual presentation of scientific data, basic office procedures, business practices, and resumé preparation. Stress will be on practical use of the material presented.

**501 Proteins and Food Enzymes**
The first part of the course deals with the general properties of proteins: structure, preparation, and reactions; the second part, with proteins as part of food systems, occurrence and composition, associations and structures, and reactions to processing. The use and application of enzymes in the food industry will be discussed.

**502 Food Lipids**
Covers the disposition of lipid materials in foods and the manner in which lipids influence the chemical and physical attributes of various foods. The effects of production techniques, storage, heating, refrigeration, and enzymes on food lipids are described, and the chemical mechanisms involved are elucidated. The importance of lipids in the formation of food flavors is discussed.

**503 Food Carbohydrates**
A consideration of the chemistry of carbohydrates in foods, including sugars, starches, pectins, gums, and cellulose. Emphasis will be placed on their origin in raw materials and the subsequent changes occurring during processing and storage.

**504 Chemistry of Dairy Products**
A study of milk constituents and physical properties. Deals with milk enzymes, lactose, milk fat, milk proteins, and minor constituents.

**505 Physical Chemistry of Foods II**
The physical chemical principles of important food systems with special emphasis on colloids and emulsions. Reaction kinetics, thermodynamics, and molecular interactions will also be considered.

**506 Instrumental Methods**
Deals with instrumental methods widely used in research and industry. The major emphasis is on chromatography, spectroscopy, electrophoresis, ultracentrifugation, thermal analysis, and the use of computers. The stress will be on the practical use of the material presented.

**507 High-Protein Food Technology**
The needs, types, processing techniques, nutritional qualities, and economics of high-protein foods for an expanding world population are examined in discussions and through individual study. Basic protein foods from cereals, pulses, oil seeds, milk, and marine life will be considered along with single-cell protein foods from whey, cellulose, leaves, and petroleum.

**508 Food Color and Food Pigments**
An introduction to theories of color perception and color spaces is followed by a survey of chemical and physical properties of the major food pigments and their stability during processing and storage. Compounds will be compared for color contributions and other functional properties. Color and pigments of selected commodities will be examined in detail.

**509 Rheology**
The course deals with the fundamental concepts of rheology as applied to foods, with emphasis on objective methods for measuring physical properties of foods. It covers the principles and practice involved in measuring of solid foods, viscosity of liquid foods, and consistency of semisolid foods, instrumentation, and correlations between objective and sensory methods of texture measurements. Examples of rheological problems in each major food group are discussed.

**510 Chemical Toxicology**
Discussions on concepts of toxicology; physiologic active substances in foods, intentional and unintentional food additives; and safety evaluation of foods. Assigned writing or student lecture will widen knowledge of current research in the area.

**599 Preparation for Food Science Teaching**
Designed to give graduate students some experience in teaching and in preparation of courses. Participants will assist professor in regular Food Science courses, including some actual teaching experience, and will attend a number of orientation lectures on teaching techniques.

**600 Seminar**
Required of all Food Science graduate students.

**Biological Sciences 394 Dairy and Food Microbiology**

**Biological Sciences 393 Applied and Industrial Microbiology**

**Animal Science 290 Meat and Meat Products**

**Animal Science 293 Meat Cutting**

**Animal Science 490 Science and Technology of Meat, Fish and Eggs**

**Vegetable Crops 312 Postharvest Handling and Marketing of Vegetables**

**Agricultural Economics 240 Marketing**

## Genetics

All courses carry Biological Sciences numbers unless otherwise stated.

**280 Human Genetics**
An introduction to biological heredity through consideration of the genetics of man. Advances in the science of genetics are having a profound effect on man's understanding of himself and on his potential for influencing his present and future well-being. The course is intended primarily to contribute to the student's general education in these matters. Not to serve as a prerequisite to advanced courses in genetics, although certain aspects of genetics will be considered with some rigor. This course is not generally regarded as a graduate course but may be so regarded in special cases.

**281A Genetics, Lectures**
A general study of the fundamental principles of genetics in eucaryotes, procaryotes, and viruses. Discussions of gene transmission, gene action and interaction, gene linkage and recombination, gene structure, gene and chromosome mutations, genetic aspects of differentiation, genes in populations, breeding systems, extrachromosomal inheritance.

**281B Genetics, Laboratory**
A laboratory course in genetics emphasizing the principles of inheritance. Students perform experiments with microorganisms and conduct an independent study of inheritance in Drosophila. Students do not preregister for laboratory sections. Laboratory assignments will be made at the end of the first lecture period of course 281A.

**347 Cytology**
A study primarily of the structure of cells and their components and the relation of these to function and to heredity. Special attention is given to chromosomes. Both plant and animal materials are used.

**347A Cytology, Lectures**
Lecture part only of 347.

**347B Cytology, Laboratory**
Laboratory part of 347.

**387 Molecular Aspects of Development**
Analysis at the cellular and subcellular level of the regulation of the synthesis and activity of gene products in the development of eucaryotes. Selected systems will be discussed which demonstrate the differential regulation of nucleic acid and protein synthesis within individual cells as well as between different populations of cells within a developing organism. Consideration will also be given to the development of cell organelle systems.

**440 Cytogenetics**
An advanced course dealing mainly with the cellular mechanisms of heredity and including recent researches in cytology, cytogenetics, and cytotaxonomy.

**480 Population Genetics**
A study of factors which influence the genetic structure of Mendelian populations and which are involved in race formation and speciation. In contrast with 484, this course deals largely with the algebraic aspects of population genetics.

**484 Molecular Evolution**
An analysis of evolutionary changes in proteins and nucleic acids and gene-enzyme variability in natural populations. The role of natural selection in effecting these changes and maintaining genetic variation at the molecular level will be critically examined. Theories on the evolution of the genetic code and the construction of phylogenetic trees from biochemical data will be discussed.

**488 Genetics of Lower Eucaryotes**
Genetic aspects of the biology of a few eucaryotic microorganisms, primarily yeast, Neurospora, and ciliated protozoa, with emphasis on the use of these organisms as experimental tools. Major topics to be covered include gene action, control mechanisms, cytoplasmic genetic systems, recombination and conversion, morphogenetic systems and evolutionary aspects of physiological systems. Extensive reading in the original literature of genetics.

**489 Research in Genetics and Development**
Practice in planning, conducting, and reporting independent laboratory and/or library research programs.

**495A Microbial Genetics, Lectures**
Genetics of bacteria and their viruses, with emphasis on the mechanisms of genetic phenomena.

**495B Microbial Genetics, Laboratory**
Problem solving in bacterial genetics.

**680 Current Topics in Genetics**
A seminar course with critical presentation and discussion by students of original research papers in a particular area of current interest. Content of the course and staff direction varies from term to term.

See also Plant Breeding 505, and courses listed under Animal Breeding, Animal Science, Biochemistry, Physiology, and Plant Breeding and Biometry.

## Geological Sciences

**312 Geography of Anglo-America**
The geographic provinces of Anglo-America, their geomorphic expression, climates, resources, development, and interrelationships.

**314 Continental Geography**
Physical geography, regional climatology, land use, and natural resources of a selected continent or region.

**322 Structural Geology—Tectonics**
Nature, origin, and recognition of geologic structures. Behavior of geologic materials, stresses, geomechanical and tectonic principles applied to the solution of geologic problems. Analysis of structural features by three-dimensional methods.

**351 Mineralogy**
Crystallography, crystal chemistry, and systematic mineralogy of the ore and rock-forming minerals.

**352 Petrology**
Composition, classification, and origin of igneous, sedimentary, and metamorphic rocks.

**421 Sedimentation**
Source materials, mechanics of transport and dispersal, depositional environments, lithification and diagenesis of sediments. Analysis of common problems in applied fields due to these phenomena.

**441 Geomorphology**
Description and interpretation of land forms in terms of structure, process, and stage.

**444 Geological Oceanography**
Shoreline erosion, transportation, and deposition; origin

and structure of continental shelves and ocean basins. Geologic processes and geomorphic development in the marine environment.

**451 Optical Mineralogy**
Optical properties of crystals and their application to the determination and study of common rock-forming minerals with the petrographic microscope.

**452 Optical Petrography**
Description, classification, and determination of the origin of igneous, metamorphic, and sedimentary rocks by the use of petrographic microscope.

**461 Mineral Deposits: Metals**
Principles and processes involved in the formation of mineral deposits. Modes of occurrence, origin, distribution, and utilization of the major, rare, and minor metals.

**462 Mineral Deposits: Nonmetals**
Properties, occurrence, associations, distribution, and economic utilization of the industrial minerals and rocks.

**471 Invertebrate Paleontology**
Paleobiology and classification of important fossil invertebrates.

**472 Principles of Historic Geology**
Application of geologic principles to interpretation of earth history: development of the geologic column; geochronology and geochronometry; correlation and the zone concept; sedimentary environments and provinces; geosynclines and platforms; problems of the Pre-Cambrian and continental evolution.

**532 Hydrogeology**
Hydrologic cycle and water provinces; occurrence, movement, quantity, and chemical quality of ground-water in porous media. Water resources development.

**533 Engineering Geology: Theory and Environments**
Advanced study of the physical phenomena and rock properties of special importance from the planning through the operation stages of engineering works; includes underground fluids, subsidence, gravity movement, seismicity, geomechanics and stresses, rock mechanics, weathering, and geologic materials of construction. Analysis of geologic problems encountered in practice; predicting the influence of natural and man-made environmental factors.

**535 Engineering Geology: Practice**
Application of geological principles in the planning-design, construction, and operation of engineering works. Case histories, analysis, and evaluation of physical environmental factors, remedial treatment, and reports.

**542 Glacial and Pleistocene Geology**
Glacial processes and deposits and the stratigraphy of the Pleistocene.

**551 Geochemistry**
Distribution of major and minor elements in the earth, geochemical cycles of the elements, and chemistry of weathering and petrogenesis.

**554 X-ray Analysis**
Theory and use of x-ray diffraction and spectroscopy in identification and analysis of minerals, rocks, and soils.

**561 Fundamentals of Mining Geology**
Principles of geological, geophysical, and geochemical techniques used in mineral exploration. Mining geology, guides to ore, mining methods.

**562 Economics of Mineral Deposits**
Sampling and ore estimation. Cutoff, grade, tonnage, and economic factors related to mining and mineral marketing. Financial calculations and procedures used in mineral property valuation.

**563 Ore Microscopy**
Identification of ore-minerals in polished sections which reflect light by etching and microchemical reactions: study and interpretation of mineral relationships.

**571 Stratigraphy: Paleozoic**
Principles of stratigraphy developed by detailed study of selected American and European systemic examples.

**572 Stratigraphy: Mesozoic and Cenozoic**
Principles of stratigraphy developed by detailed study of selected American and European systemic examples.

**581 Exploration Geophysics**
Elementary theory and interpretation of data from exploration geophysical methods. Environmental geology and selection of techniques for important applied areas.

**582 Exploration Geology**
Methods of exploration and appraisal of geologic data from both field and laboratory investigations. Assessment of environmental geology and the presentation of direct and indirect information for professional purposes and applied fields. Recommended for all graduate students in geological sciences.

**583 Physics of the Earth**
Theory and field measurements of the earth's gravitational, magnetic, seismic, electrical, thermal, and radioactive properties.

**584 Seismology**
Theory of stress and strain, seismic wave propagation, earthquake studies, and observational seismology.

**586 Seminar in Rock Deformation: Geomechanics**
Review of stress analysis and behavior of materials, both the rock mass and sample. Fundamentals of deformation pertaining to the crustal rocks and the problems of applied geological science.

**610 Special Work**
Special or original investigation in physical geography.

**653 Advanced Petrology**
Readings and discussions on the petrogenesis of igneous rocks. Laboratory studies of selected igneous rock soils.

**656 Advanced Mineralogy**
A theoretical treatment of the crystal chemistry and thermodynamics of rock-forming minerals.

**672 Stratigraphy of New York State**
The classic Paleozoic sections of New York studied through lectures, readings, and field observation.

**673 Seminar in the History of Geology**

**690 Special Work**
Advanced work on original investigations in geological sciences.

**690-a Analytical Geochemistry, Crystallography, and Mineralogy**

**690-b Petrology and Geochemistry of Metamorphic and Igneous Rocks, Associated Metallic Minerals**

**690-c Coastal Geomorphology and Pleistocene Geology**

**690-d Engineering Geology, Geomechanics, and Hydrogeology**

**690-e Seismology, Crustal and Marine Geophysics, Heat Flow**

**690-f Invertebrate Paleontology and Paleoecology**

**690-g Sedimentology and Primary Structures**

**690-h Physical and Engineering Geology, Water Resources**

**690-i Mineral Deposits and Resources, Exploration Geophysics**

*Note:* A seminar for no credit, required of all graduate students in the geological sciences, will be held each term to report on and discuss current research in the geological sciences.

## Germanic Studies

**401-402 History of the German Language**

**403 Linguistic Structure of German**
A descriptive analysis of present-day German, with emphasis on its phonetics, phonemics, morphology, and syntax.

**404 German for Teachers**
Methods of teaching the language based on a contrastive study of the structures of English and German. Extensive outside reading, reports on textbooks, discussion of various teaching aids and realia.

**405-406 Introduction to Medieval Literature**
Intended for students with no previous knowledge of Middle High German. Begins with study of the Middle High German language and then proceeds to the reading of selected texts.

**408 Topics in Earlier German Literature: 1300–1700**

**410 Topics in Classicism and Romanticism**

**412 Modern Dramatists**

**413, 414 Topics in Modern German Literature I and II**

**415 Bibliography and Methods**

**417, 418 The Great Moments of German Literature**
Recommended for graduate students, whether majoring in German or not, who wish to acquire an overall view of the whole range of German literature from the earliest texts to the present day. The only prerequisite is a reading knowledge of German. Two weekly lectures will aim at a characterization of the temper of a period or of the essential nature of a certain writer. A discussion period will concentrate on individual works illustrative of the topics of the lectures.

**424 Old Norse Sagas in English Translation**

**501 Introduction to Germanic Linguistics**

**502 Gothic**

**503-504 Old Saxon, Old High German, Old Low Franconian, Old Frisian**

**509-510 Old Norse**
The grammar and phonological history of the language will be treated, and the student will be introduced to representative selections from the literature of Old Icelandic.

**511 Sagas**

**513 Seminar in Old Norse Language and Literature**

**514 Skaldic Poetry**

**520 Germanic Mythology**

**521 Middle High German Literature I**
Topic: The courtly epic. Emphasis on Wolfram von Eschenbach.

**522 Middle High German Literature II**
Topic: The Nibelungen legend and its literary manifestations.

**523 German Literature of the Late Middle Ages**

**525 Sixteenth-Century German Literature**

**527 Seventeenth-Century German Literature**

**530 Topics in Eighteenth-Century Literature other than Goethe**

**531 Topics in Goethe**

**533 German Romanticism**

**535, 536 Topics in Nineteenth-Century German Literature**

**538, 539 Topics in Twentieth-Century German Literature**

**540 History and Methods of Modern German Literary Criticism**

**541 The Postwar German Novel**

**599 Colloquium on the Teaching of Literature**
Open to teaching assistants in the Department of German Literature. Composed of all faculty members and assistants teaching undergraduate courses.

**621-622 Computer Methods in Germanic Studies**
The use of the computer in analyzing Germanic texts, including modern Germanic languages. Practical experience in using text processing programs.

**641-642 Seminar in Scandinavian Linguistics**
Selected topics including history, structure, and dialects of selected Scandinavian languages.

**651-652 Seminars in Germanic Linguistics**

**653-654 Seminar in German Literature**

**661-662 Seminar in Comparative Germanic Linguistics**

**671-672 Seminar in German Linguistics**
Selected topics including the history, structure, and dialects of modern German.

**681-682 Seminar in Dutch Linguistics**
Selected topics including the history, structure, and dialects of modern Dutch.

See also courses listed under the Field of Comparative Literature and the Field of History.

## Government

### American Politics

**503 Field Seminar in American Politics**
Introduction to some of the major research areas in American politics: parties and elections; legislative behavior; leadership (especially the presidency); judicial behavior; comparative state politics; and policy analysis. The reading will illustrate a variety of analytical approaches and techniques. Short critical and synthetic papers will be assigned.

**512 Urban Political Participation and Public Policy**
An analysis and evaluation of political activity aimed at problems of the urban environment. Particular attention will be given to different forms of such participation, by various elements in the urban polity, and the conditions of their effectiveness.

**513 Legislative Behavior**
An analysis of legislative action including elections, constituency relations, norms, roles, leadership, committees, policy, and environmental effects. The emphasis is on the U.S. Congress, with supplementary attention

to comparative state legislative politics. Short critical papers and one short empirical paper are assigned.

**514 American Urban Politics**
An attempt to familiarize the student with important perspectives and literature on the problems of governing American urban areas. Extensive reading, discussion of the main theoretical approaches, and short synthetic papers will characterize this seminar.

**517 Judicial Behavior**

**518 Politics, Law, and the Constitution**

**520 Public Opinion and Public Policy**
The seminar will analyze intensively the linkages between public opinion and public policy in the context of the political system. Specific topics will include the perception of policies, the impact of opinion on public policy formation and implementation, the symbolic uses of politics, and variation in opinion-policy interaction across different policy areas.

**525 American Political Behavior**
An examination of current research in such areas of American politics as political socialization, ideology, political participation, elite recruitment, and political behavior in small groups. Both substantive and methodological issues will be discussed with particular attention to the gaps in existing studios and the goals of future research.

**526 American Political Behavior: Research Projects**
This seminar will involve (1) a critical analysis of research on American political behavior and (2) the design and execution of original research based on existing data. Particular attention will be given to the areas of political socialization, public opinion, and political participation, though additional areas of interest may also be considered. No previous empirical research experience is required.

## Comparative Politics

**505 Field Seminar in Comparative Politics**
A critical review of the advantages and limitations of comparative inquiry. Particular attention will be given to the theoretical, conceptual, and methodological issues involved in comparative research. Examination of the various units of comparative inquiry, individuals, groups, institutions, and national systems, as well as problems of generalization and validation across cultures and time.

**534 Politics of the Soviet Union**

**535 Problems of Political Succession**

**537 Political Development and Social Change (Business and Public Administration 631)**
Critical analysis of the relationship between socioeconomic change and the emergence of political institutions in new states. Emphasis will be on issues of participation, redistribution of power, and policy formation relating to developmental goals. The major theories of political development will be reviewed in the light of developing countries.

**539 Politics of the Future of Europe**
An exploration of political issues which relate to the next twenty years of European development. After a brief survey of the techniques of future-analysis and of the postwar history of Western Europe and Great Britain, the seminar will examine such topics as political unification and regionalization, foreign policy and military strategy, social and economic planning (including town planning), technological and economic innovation, political participation, and the "New European Man."

**540 Government and Politics of Latin America**
A seminar conducted in conjunction with the undergraduate course, 340. Initial sessions will consist of an elucidation and critique of common conceptions of Latin American politics, as presented in the lectures and readings of 340. In subsequent sessions seminar members will "test" these and alternative conceptions against the evidence found in episodes of Latin American politics. Those interested in this seminar should discuss it with the instructor.

**541 Comparative Political Parties**

**543 Politics of Communalism**
A study of the politics of racial, ethnic, religious, linguistic, and cultural pluralism. The emphasis will be on subnational pluralism, the implications of communal cleavages for political and economic development, and strategies for the management of various expressions of communal conflict. The seminar will focus on relationships between modernization and communal pluralism, but will not exclude the manifestations of these phenomena in industrialized societies. It will *not* deal with contemporary U.S. experience.

**544 Comparative Local Politics (Business and Public Administration 562)**
An analysis of how subnational policy processes and political structures relate to national politics. Particular attention is given to how participation and party activity at the local level may or may not influence local policies, and the extent to which citizens may or may not exercise policy control. A comparative approach will be used involving England, France, and several developing countries.

**547 Politics of China**
A seminar on the post-1949 Chinese political system, with particular attention to the problems and tensions confronting the regime. Each student will prepare a substantial research paper on some aspect of contemporary Chinese politics.

**548 Comparative Communism**
An investigation into the similarities and differences between Communist regimes, with particular emphasis on the Soviet Union and Communist China.

**560 Political Economy of Change: Strategies of Rural Development**
This seminar is organized to serve substantive and analytical purposes. The substantive focus is on economic, social, and political change in Third World countries and particularly on strategies for rural development. The analytical approach used is a new version of political economy which integrates economic, social, and political factors into a common framework. As an intellectual enterprise, this seminar is intended to contribute to the development of a social science useful for achieving public purposes and capable of informing political choices, with special reference to the Third World.

**546 European Parties and Participation**
An empirical analysis of how patterns of participation, voting, and party involvement affect the European party system, with special reference to France and Italy. The seminar will include the socioeconomic, regional, and historic influences on participation and party structure in European politics.

## International Relations

**509 Field Seminar in International Relations**
A general survey of the literature and propositions of the international relations field. Criteria will be developed for judging theoretical propositions. These will then be

applied to the major findings. Participants will be expected to do extensive reading as well as engage in certain research activities.

**561 Science, Technology, and International Relations (Business and Public Administration 640)**
This seminar will focus on science/technology relations among advanced industrialized countries and the foreign policy implications of scientific and technological change. It will deal with problems of domestic science/technology policy, national structures established to operate in this field, the activities of international and regional organizations, especially OECD, the substantive interactions between international organizations and national policies, the meaning of so-called technology and management "gaps," and the consequences of international cooperation and conflict (including East-West) for peace, economic growth, and quality of life. (This is the second of a two-course sequence in international science and technology; the first deals with science and technology transfer between industrialized and less developed countries.)

**571 Quantitative International Politics**
Recent quantitative approaches to the analysis of international politics will be briefly surveyed. Individual research projects will focus on a specific problem in international politics, such as the relation between public opinion and foreign policy or the definition of power.

**573 The U.N. and the Third World**
A study of the impact of the rise of the Third World on U.N. political processes and functions and of United Nations interests and role in Third World development. Among the issues discussed will be the changing nature of U.N. interests and behavior; changing functions of international law; expansion of U.N. international peace and security functions; the internationalization of political conflicts in developing areas; U.N. role in political change (especially on self-determination issues) and socioeconomic development; and Third World and U.N. approaches to regionalism and functionalism.

**574 Analysis of Foreign Policy**

**575 International Organization and World Politics**

**577 Political Problems of Southeast Asia**
An examination of great power interests and involvement with the states of Southeast Asia with reference to the policies of China, the Soviet Union, the United States, and Japan, with some consideration of Britain's changing role.

**578 Research Seminar on the United States Presence in Latin America (Sociology 648)**
The general theme of this interdisciplinary seminar is the impact which North American institutions—cultural, economic, political—have upon contemporary Latin American societies. The precise focus shifts from year to year.

**583 Communist China in International Politics**
An analysis of major problem areas in the Chinese People's Republic external relations, with special emphasis on Chinese foreign policy strategy and doctrine.

## Political Thought

**507 Field Seminar in Political Thought**
An introduction to political theory through a reading of selected classics in political thought from Plato to Marx.

**528 American Political Thought**
Four major areas in American political thought are stressed: Puritan notions of authority and citizenship; the political thought of the revolutionary and early constitutional period; "progressive" scholarship; and contemporary American political science.

**553 Political Philosophy**

**554 Classical Political Philosophy**

**556 Political Theory: Origins of English Liberalism**

**558 Nineteenth-Century Social Thought**
The seminar will examine some problems of democratic theory and political analysis through reading and discussion of selections from the works of Tocqueville, Marx, Bentham, J. S. Mill, and others.

**559 Twentieth-Century Social Thought**
The seminar will center on the works of Freud, Weber, and Durkheim and will examine some of the major methodological problems that these theorists raise for contemporary social and political thought.

## Public Policy and Politics

**506 Field Seminar on Public Policy (Business and Public Administration 557)**
This seminar is intended as an introduction to the study of public policy. Various analytical approaches will be presented: models of public choice and political economy; analysis of bureaucratic politics, executive and political leadership, and interest groups and public opinion; economic analysis of public finance and welfare economics; and organization theory, game theory, and decision theory as these relate to the analysis of public policy formation and applications.

## Methodology of Politics

**501 Reading Seminar on Contemporary Political Inquiry**
A survey of the major theoretical and conceptual issues in the discipline. An attempt will be made to assess the relevance of other disciplines to the analysis of political behavior.

**502 Reading Seminar in Political Research Design**
Major problems in the design of political research in a nonexperimental context will be examined, including sampling, questionnaire construction, coding, machine storage of data, and elementary data analysis. Both primary and secondary research will be discussed, with illustrative examples drawn from elite, public opinion, and international politics research.

**504 Personality and Politics**
An intensive survey of limitations and accomplishments of personality psychology as applied to political behavior. Topics include authoritarianism, dogmatism, political paranoia, fate control, Machiavellianism, the need for power (neurotic and otherwise), moral maturity, Tomkins' theory of left and right personality, political biography, radical protest movements, and leadership styles. Focus is interdisciplinary.

# History

## American History

**372 The Origins of American Civilization**

**373, 374 The Structure of American Political History**

**375 The American Civil War and Reconstruction**

**376 American Cultural and Intellectual History, 1600–1860**

**377 American Cultural and Intellectual History, 1860–1960**

**379 American History, 1890–1917**

**380, 381 Recent American History, 1917 to the Present**

**383 History of American Foreign Relations, 1750–1914**

**384 History of American Foreign Relations Since 1914**

**385 Problems in the History of the Old South, 1606–1860**

**387 The South since Reconstruction, 1877–1960**

**388-389 Race and Ethnicity in American History**

**470 The United States in the Middle Period, 1815–1850**

**471 Problems in American Political History**

**473 Age of the American Revolution, 1783–1815**

**474 Nationalism and Nostalgia in American Life, 1870–1930**

**475 American Historiography in the Middle Period**

**476 Problems in American Cultural History**

**477 Topics in American Constitutional Development**

**481, 482 American History: History of the West**

**483 Problems in the History of the South**

**484 Motivations of American Foreign Policy**

**502 Colloquium in American History**
Required of all entering graduate students in American history.

**669-670 Seminar in Early American History**

**673-674 Seminar in Nineteenth-Century American History**

**675-676 Seminar in American Cultural and Intellectual History**

**679-680 Seminar in Recent American History**

**681-682 Seminar in the History of the American West**

**683-684 Seminar in the History of American Foreign Relations**

**685-686 Seminar in the History of the American South**

**688-689 Seminar in American Social History**

## Asian History

**393 History of Chinese Civilization Prior to the Nineteenth Century**

**394 History of Chinese Civilization: Nineteenth and Twentieth Centuries**

**492 The Medieval Chinese World**

**495 Southeast Asian History to the Fourteenth Century**

**496 Southeast Asian History from the Fifteenth Century**

**497 Southeast Asia in the Nineteenth Century**

**588, 589 The Historiography of Southeast Asia**

**591 Chinese Historiography and Source Materials**

**593 Modernization of China**
A discussion seminar.

**594 Modernization of China**
A research seminar.

**691-692 Seminar in Medieval Chinese History**

**693-694 Seminar in Modern Chinese History**

**695, 696 Seminar in Southeast Asian History**

## Ancient European History

**631-632 Seminar in Ancient Classical History**

## Medieval and Early Modern European History

**335 Medieval Culture, 400–1150**

**336 Medieval Culture, 1150–1300**

**341-342 Europe in the Age of the Renaissance, Reformation, and Counter-Reformation**

**437 Church and State during the Middle Ages**

**442 Catherine de Medici and the French Wars of Religion**

**635, 636 Seminar in Medieval History**

**637, 638 Seminar in Medieval History**

**639-640 Seminar in Latin Paleography**

**641-642 Graduate Seminar: The Theory and Practice of Reason of State**

## Modern European History

**344 War, Trade, and Empire, 1585–1815**

**345 Europe in the Seventeenth and Eighteenth Centuries**

**346 The Era of the French Revolution**

**347 English Constitutional History I: To 1485**

**348 English Constitutional History II: Since 1485**

**351 Europe in the Nineteenth Century**

**352 Europe in the Twentieth Century**

**353, 354 European Intellectual History in the Nineteenth and Twentieth Centuries**

**355, 356 Modern German History**

**444 The Age of Enlightenment**

**449 History of England under the Tudors and Stuarts**

**450 England since 1870**

**451 The English Civil War, 1640–60**

**454 Topics in Modern European Intellectual History**

**456 German Problems in Historical Perspective**

**457 Government and Society in Seventeenth-Century France, from Louis XIV to Henry IV**

**461 Economic and Social History of Russia**

**462 History of Russian Foreign Relations for the Fifteenth Century**

**467 Intellectual Currents of the Seventeenth Century**

**553 Revolution in France, 1789–1848**
Conducted as a seminar.

**551 The French Republic in the Twentieth Century**
Conducted as a seminar.

**645-646 Seminar in Modern British History**

**647-648 Seminar in Tudor and Stuart History**

**649 Historical Demography and Social Structure: Comparative Studies in the Old Regime, Europe and America**

**650 Seminar in the French Revolution**

**651-652 Seminar in Modern European History**

**653-654 Seminar in Modern European Intellectual and Cultural History**

**657-658 Seminar in Modern German History**

**659 Seminar on Eighteenth-Century French Social History**

**661-662 Seminar in Russian History**

## History of Science

**311-312 Science in Western Civilization**

**369, 370 Science since 1850**

**444 The Age of Enlightenment**

**445 Problems in the History of Biology**
History of the evolutionary hypothesis from earliest times to the present.

**446 Problems in the History of Biology**
History of developmental biology, especially the mechanism vs. vitalism controversy; and the rise of molecular biology.

**663, 664 Seminar in the History of Biology**

**655 Seminar in the History of Early Modern Science**

**667-668 Seminar in the History of Science during the Nineteenth and Twentieth Centuries**

## Latin American History

**487 Slavery and Abolition in the Americas**

**488 Seminar in the History of Brazil**

**489 Seminar in Latin American History**

**687-688 Seminar in Latin American History**

## Reading Courses

**511-512 Supervised Reading**

# History of Architecture and Urban Development

The following courses carry Architecture, Policy Planning and Regional Analysis (PPRA), and Urban Planning and Development (UPD) numbers. The student may register in any of these three areas.

**Architecture 435-UPD 602 Architecture and Planning in the Orient**
An introduction to the evolution of architecture and urbanization in India, China, Thailand, Cambodia, and Japan.

**Architecture 462-UPD 601 Use of Archival Materials**
Examination of methods of archival research in the history of architecture and urban development, using manuscripts, drawings, correspondence, and documents in the Cornell University Archives and Regional History collections.

**Architecture 465-PPRA 644 Design and Conservation**
The rationale for the methods of utilizing existing cultural and aesthetic resources in planning and design of regions and cities.

**Architecture 466-PPRA 645 Documentation for Preservation Planning**
Methods of collecting, recording, processing, and analyzing architectural and cultural survey materials.

## Architectural History

The following courses carry Architecture numbers.

**430 The Ancient Near East**
Architecture of the oldest historic civilizations associated with Western tradition, with emphasis on Egypt and Mesopotamia.

**431 The Classical World**
Architecture of the ancient Mediterranean civilizations, especially Greece and Rome.

**432 The Early Middle Ages (History of Art 333)**
Sculpture, painting, and architecture from 300 to 1050 A.D.

**433 The Middle Ages (History of Art 335)**
Art and architecture in Western Europe during the Romanesque era.

**434 Islamic Architecture**

**436 The Renaissance**
Italian architecture of the fifteenth and sixteenth centuries.

**437 The Baroque**
European architecture of the seventeenth and eighteenth centuries.

**438 American Architecture**
Building in the U.S. from colonial times, with emphasis on the nineteenth and twentieth centuries.

**439 Modern European Architecture (History of Art 367)**
A survey of nineteenth- and twentieth-century architecture in Europe.

**448-449 Historical Lectures in Architecture**

**451-452 Historical Seminars in Architecture**
Qualified students will prepare papers on problems relating to design or architecture, using historical evidence as the basis.

**455 Special Investigations in the History of Architecture**

**460-461 Introduction to Architectural Aspects of Archaeological Field Work**
For architects, archaeologists, and laymen. An investigation of architectural techniques used in archaeology.

**467-468 Informal Study in the History of Architecture**

**473 Seminar in Medieval Art and Architecture (History of Art 531)**

**476 Seminar in the History of Renaissance Architecture**

**477 Seminar in the History of Baroque Architecture**
Historical problems in European architecture of the seventeenth and eighteenth centuries.

**478 Seminar in the History of American Architecture**
Investigation by means of reading, lectures, and reports of historical problems in architecture of the nineteenth and twentieth centuries in the United States.

**479 Seminar in the History of Modern Architecture**
Historical problems in modern art and architecture.

**488 Problems in Modern Architecture**

**491-492 Thesis in Architectural History**
Independent research by candidates for the Master's degree.

**497-498 Dissertation in Architectural History**
Advanced independent research by candidates for the Ph.D. degree.

## Planning History

The following courses carry Planning numbers.

**UPD 640 Seminar in Urban Design**
Investigation of historical and current thought on the visual aspects of cities, including evaluation of technological and cultural influences on urban design, perception of urban form, and relationships between contemporary city planning process and visual form in cities.

**UPD 400/500 Historical Development of the World's Cities I**
Historical methods and research techniques; case studies and aesthetic evaluation; the urban revolution; classical societies; medieval urbanism; the Renaissance and the baroque in Europe; colonization and North America.

**UPD 401/501 Historical Development of the World's Cities II**
Introduction; the social, philanthropic, and planning movements from the eighteenth century to World War II; Industrial Revolution and technological change; reform; public health, housing, model industrialists; research techniques; planning pioneers and theorists; garden and lineal cities, high- and low-density solutions; new town theories.

**UPD 603 Seminar in the History of American City Planning**

**UPD 605 Introduction to the History of Landscape Architecture and Design**
Classical landscape in the Mediterranean and the Middle East; the Islamic Byzantine tradition; medieval cityscape and the agrarian system; the Renaissance; landscape of gardens in Persia, India, China, Thailand, and Japan. The Victorians; landscape in North America; colonial landscape, the twentieth century; horticulture and techniques; landscape in contemporary planning and architecture.

**UPD 604 The History of Colonial Planning**
Colonial city planning and civic design in Africa, America, Asia, and Australasia.

**UPD 709 Informal Study in the Historical Development of Urban Areas**

**PPRA 699 Thesis in Urban Planning and Development**
Independent research by candidates for the Master's degree.

**PPRA 799 Dissertation in Urban Planning and Development**
Advanced independent research by candidates for the Ph.D. degree.

# History of Art and Archaeology

## History of Art

**313 Prehistoric Art**

**314 Primitive Art: The Art of Tribal Societies**

**315 Pre-Columbian Art**

**333 Early Medieval Art**

**334 Romanesque Art**

**335 Gothic Art**

**336 Medieval Italian Art**

**341 Flemish Art**

**342 Medieval and Renaissance German Art**

**343 Italian Renaissance Art of the Fifteenth Century**

**344 Italian Renaissance Art of the Sixteenth Century**

**347 Art of the Early Renaissance in Italy**

**349 Italian Renaissance Architecture**

**354 Dutch Painting of the Seventeenth Century**

**355 French Art of the Sixteenth and Seventeenth Centuries**

**356 Art of the Seventeenth and Eighteenth Centuries**

**357 European Art of the Eighteenth Century**

**363 Modern Painting**

**367 Modern European Architecture**

**376 Modern American Art**

**380 Comparative Genres in East-West Art**

**381 Buddhist Art in Asia**

**383 Art of China**

**384 Art of Japan**

**385 Chinese Painting**

**386 Studies in Indian Art**

**392 Latin American Art**

**411 Techniques and Materials: Painting**

**412 Techniques and Materials: Graphics**

**431 Greek Sculpture**

**432 Arts of the Roman Empire**

**446 Literary Sources in the Italian Renaissance**

**448 Mannerism and the Early Baroque in Italy**

**458 Classic and Romantic Art**

**462 Art and Technology: 1850–1950**

**472 Romanticism in Painting**

**481 Masters of Japanese Prints**

**482 Ceramic Art of Asia**

**510 Seminar in Latin American Art**

**531 Problems in Medieval Art and Architecture**

**548 Studies in Italian Renaissance Art I**

**549 Studies in Italian Renaissance Art II**

**552 Studies in English Art**

**563 Problems in Twentieth-Century Art**

**564 Problems in Twentieth-Century Art**

**565 Problems in Modern Art and Architecture**

**572 Problems in American Art**

**580 Problems in Asian Art**

**584 Problems in Chinese Art**

**586 Studies in Chinese Painting**

**588 Southeast Asian Art and Archaeology**

**591-592 Supervised Reading**

**595 Methodology Seminar**

## Archaeology

Students who are interested in archaeology are directed especially to History of Art 313, 314, 432, and 588, all of which include archaeological material. The following specialized courses treat specific excavational material and procedures, and are therefore open only to a limited number of students who have some background in ancient history, ancient languages, anthropology, or art history.

**521 Numismatics**

**523 Ceramics**

## Hotel Administration

For descriptions of the following courses, see the *Announcement of the School of Hotel Administration.*

**117 Seminar in Organizational Behavior and Administration**

**125 Lectures on Hotel Management**

**127 Franchising in the Hospitality Industry**

**128 Principles of Management**

**190 Special Studies in Research**

**223 Investment Management**

**226 Tax Basis for Managerial Decisions**

**227 Seminar in Financial Management**

**228 Internal Control in Hotels**

**291-293 Special Studies in Research**

**335 Restaurant Management**

**345 Special Problems in Food**

**361 Special Studies in Research**

**415 Law of Business: Contracts, Bailments, and Agency**

**416 Law as Related to Innkeeping**

**417 Law of Business: Business Organization-Partnerships and Corporations**

**490 Special Studies in Research**

**527 Hotel Planning**

## Human Development and Family Studies

**323 Cognitive Processes**

**324 Piaget's Theory of Cognitive Development**

**334 Advanced Participation in Community Groups**

**336 Special Problems in Relation to Exceptional Children**

**342 The Development of Creative Thinking**

**343 Creative Expression and Child Growth**

**358 Theories of the Marital Dyad**

**360 Personality Development in Childhood**

**362 The Family and Society**

**372 Perspectives on Poverty**

**374 Behavior and Development in Infancy**

**376 Research Practicum on the Family in Poverty**

**390 The Evolution of Female Personality: History and Prospects**

**397 Experimental Child Psychology**

**401 Theories of Child Development**

**425 Applied Cognitive Psychology**

**464 Selected Problems in Emotional and Intellectual Deviations in Children**

**465 Innovative Programs of Parent Intervention and Community Action**

**472 Practicum in Community Change and Consultation**

**500 Special Problems for Graduate Students**

**504 Research Problems and Methods in the Study of Development**

**508 Seminar in Theories of Intelligence**

**514 Clinical Deviations in Intellectual and Sensory-Motor Development**

**517 Practicum in Early Childhood Education**

**520 Issues in Developmental Psychology**

**522 Seminar in Cognitive Development**

**523 Seminar in Cognitive Processes**

**540 Human Development and Formal Organizations**

**560A, 560B Seminar in Psychopathology**

**562 The Family, Society, and the Individual**

**564 Family and Kinship**

**574 Seminar in Infant Behavior and Development**

**580 Seminar on Adolescent Behavior**

**595 A Process Approach to Early Education**

**599 Master's Thesis and Research**

**609 Seminar in Projective Techniques**

**611 Evaluation Practicum: Study of the Individual Personality, Deviant and Normal**

**613 Individual Intelligence Test Procedures**

**615 The Development of Human Behavior**

**621 Seminar in the Development Study of Social Behavior**

**622 The Nature of Subjective Reality**

**623 Seminar in the Development of Language**

**660 Personality Development in Childhood**

**699 Doctor's Thesis and Research**

## Human Nutrition and Food

**441 Nutrition and Disease**
Study of the physiological and biochemical anomalies in certain diseases and the principles underlying nutritional therapy. Independent survey of the technical literature in this field. Some laboratory work on nutrient composition of food, physiological response to different diets, and methods of determining dietary patterns of individuals.

**445 Community Nutrition and Health**
Study of biological and environmental dimensions of human nutritional problems in contemporary society; application of basic concepts of food and nutrition to the improvement of man's health; evaluation of federal,

state, and community programs focused on improving man's nutrition. Laboratory work includes (a) developing materials for field studies and evaluation and (b) projects and field trips in nearby communities. Field experiences will be selected and developed to expose students to food and nutrition problems of man over his entire life span. Estimated cost $5.

**446A Physiochemical Aspects of Food**
The relation to food quality of *(a)* rheological properties of food systems, *(b)* oxidation and reduction reactions, *(c)* enzymatic and nonenzymatic browning. Physical and chemical factors accounting for the color, flavor, and texture of natural and processed foods.

**446B Physiochemical Aspects of Food, Laboratory**
Laboratory experiments designed to illustrate the effect of varying ingredients and treatment on the quality characteristics of food products. Objective testing methods are used to determine food quality characteristics.

**446C Physiochemical Aspects of Food, Laboratory**
Laboratory experiments designed to illustrate *(a)* the physiochemical behavior of colloidal systems; *(b)* chemical reactions of some food components; *(c)* effects of temperature, pH, moisture, inorganic salts and enzymes on physiochemical changes in natural foods, food components, and food mixtures.

**456 Experimental Food Methods**
Application of the scientific method in the design and performance of experimental food problems and in the interpretation and evaluation of results. Evaluation of the use of instruments, chemical and sensory methods in the measurement of food properties. Independent laboratory problems.

**478 Volume Food Production**
Menu planning and evaluation relative to production capacity, cost, and nutritive quality. Food contamination and principles of sanitary handling and holding of ingredients and menu items. Techniques of processing and production scheduling.

**488 Volume Food Production Practice**
Practice experiences will be arranged in one of the food service units on campus, in health-care facilities and other community facilities for students to become familiar with quantity production and food service in an operating situation.

**500 Special Problems for Graduate Students**

**501-504 Advanced Nutrition Series**
See listing under Field of Nutrition.

**512 Nutrition and Growth**
Aspects of human physical and chemical growth of particular interest to nutritionists. Survey of methodology; comparison of individual growth patterns of selected body dimensions with group patterns; consideration of some of the variables, including diet, which influence growth.

**514 Readings in Nutrition**
Critical review of literature on selected topics in the field of nutrition. Emphasis on human nutrition. Topics are changed each term so the course may be repeated for credit with permission of the instructor.

**515 Seminar in Perspectives of Human Nutrition and Food**
An introduction to food and nutrition for graduate students who have had limited or no work in this area. The seminar utilizes the lecture and discussion of 115A as a basis for supplementary readings and critical review of research on selected nutritional problems.

**516 Readings in Food**
Critical review of selected topics in the current literature. Emphasis on experimental data and basic scientific principles underlying modern theory and practice relative to food quality. Topics are changed each term so the course may be repeated for credit.

**524 Research Methods in Human Metabolic Studies**
Principles of human metabolic research; experimental design of human studies; dietary considerations; methods of collecting and analyzing biological material; and evaluation. Laboratory will include planning and management of a metabolic study, collection and analyses of blood, urine, and feces.

**526A Special Topics in Food**
A study of polysaccharides of importance in food products including starches, starch derivatives, pectins, and other neutral and acidic carbohydrate polymers. The topics will include the relationships between chemical structure and physical properties, role of starch granule structure, stability of the polysaccharides, nutritive value, solution and gel properties of the polymers, and their role in food products. May be repeated for credit with permission of the instructor.

**526B Special Topics in Food**
Irradiation of food including (1) applications in food processing, (2) beneficial and deleterious effects, and (3) chemical and biochemical changes induced in food components. May be repeated for credit with permission of instructor.

**568 Special Topics in Dietetics**
Consultation techniques for dietitians.

**578 Data Processing Applied to Dietary Department Administration**
Includes an introduction to the fundamental elements and functions of data processing equipment; basic concepts of programming, development of programs for the procurement and issuing of food commodities, the processing of ingredients, and the scheduling of departmental resources as related to automatic data processing.

**588 Advanced Layout and Equipment Selection for Dietary Departments**
Current trends in facilities and systems in dietary departments with projections for the future. Field trip, estimated cost $5.

**599 Master's Thesis and Research**

**605 Seminar in Human Nutrition and Food**
In the fall term, primary emphasis will be on nutrition; in the spring, on food science.

**608 Seminar in Administrative Dietetics**

**699 Doctoral Thesis and Research**

**Graduate School of Nutrition 580 International Nutrition Problems, Policy, and Programs**
A review of food and nutrition problems, policy, and programs especially as they relate to developing countries. Emphasis is placed on the need to coordinate the efforts of various government departments including those of agriculture, education, economics, health, and community development.

**Graduate School of Nutrition 620 General Nutrition**
This course is offered to students whose principal academic training has been in a field other than nutrition. It is designed to meet their need for a basic but intensive introduction to the principles, history, and application of nutrition.

**Graduate School of Nutrition 650 Clinical and Public Health Nutrition**
Designed to familiarize the student with some of the

applications of nutrition to clinical and public health problems.

# Industrial and Labor Relations

## Collective Bargaining, Labor Law, and Labor Movements

**500 Collective Bargaining I**
A comprehensive study of collective bargaining with special emphasis on philosophy, structures, process of negotiations, and administration of agreements. Attention is also given to problems of handling and settling industrial controversy, the various substantive issues, and important developments and trends in collective bargaining.

**501 Collective Bargaining II**
A detailed study of contract making and administration with particular reference to recent trends and problems in collective bargaining. Attention will be given to several representative industries, and prevailing agreements and case problems will be studied. A major research paper is usually required.

**502 Labor Relations Law and Legislation**
A survey and analysis of the labor relations law with an examination of the extent to which the law protects and regulates concerted action by employees in the labor market. The legal framework within which the collective bargaining takes place is analyzed. Problems of the administration and enforcement of the collective agreement are considered, as are problems of protecting the individual member-employee rights within the union.

**503 Arbitration**
A study of the place and function of arbitration in the field of labor-management relations, including an analysis of principles and practices, the law of arbitration, preparation of briefs or oral presentation, and the work of the arbitrator, umpire, or impartial chairman.

**504 Labor Dispute Settlement**
An examination of the various governmental techniques for dealing with labor disputes, in both the private and public sectors, including mediation, fact finding, arbitration (both voluntary and compulsory), the use of injunctions, and seizure. The course will also examine the application of these techniques under the Railway Labor Act, Taft-Hartley Act, and various state acts.

**505 Labor Union History and Administration**
A presentation of the history of labor in America, with some reference to colonial and early nineteenth-century labor, but with emphasis upon post-Civil War trade union development. An analysis of the structure and functions of the various units of labor organization, ranging from the national federation to the local union. Some consideration will be given to special problems and activities, such as democracy in trade unions and health and welfare plans, as well as to various types of unions.

**506 Readings in the History of Industrial Relations in the United States**
A seminar covering, intensively and in historical sequence, key documents, studies, legislative investigations, and memoirs concerning American industrial relations systems. Primarily designed to aid students in orienting themselves systematically and thoroughly in the field. Among the authors and reports covered are Thompson, Commons, Ware, Ulman, the Hewitt and the Blair hearings, the U.S. Industrial Commission, Taft, Brissenden, the U.S. Commission on Industrial Relations, Glocker, Barnett, Taylor, Gantt, Follett, Bernstein, and Galenson.

**507 Theories of Industrial Relations Systems**
An examination of the leading theories concerning the origins, forms, organization, administration, aims, functions, and methods of industrial relations systems. Among the theories studied are those formulated by Marx, Bakunin, Sorel, Lenin, Brentano, the Webbs, Croly, Gramsci, Perlman, Tannenbaum, the Guild Socialists, Polanyi, Kerr, Harbison, Dunlop, and Myers.

**509 Readings in the Literature of American Radicalism and Dissent**
Each term this course will concentrate on a different historical aspect of American radicalism and dissent. Examples of the possible range of topics and writers include: *agrarian reform,* Skidmore, Evans and Donnelly; *anarchism,* Warren, Haywood, Goldman, and Goodman; *communism,* Reed, Lovestone, and Foster; *economic dissent,* George, Veblen, and Townsend; *equal rights for Negroes and black nationalism,* DuBois and Garvey; *fascism,* Father Coughlin and Smith; *peace movements,* Addams, Balch, and Muste; *religious radicalism,* Williams, Paine, and Ingersoll; *social planning,* Noyes and Sanger; *socialism,* Byllesby, Heighton, De Leon, Hillquit, and Walling; *utopianism and communitarianism,* Bellamy, Brisbane, and Wright; and *women's rights,* Fuller, Stanton, and Anthony.

**550 Manpower and Collective Bargaining Problems in the Construction Industry**
The seminar will examine selected problems such as: supply and demand of construction manpower; the Negro and the building trades; skilled manpower forecasting and planning; skill requirements; education and training; personnel management policies and practices; the wage-price issue; the closed shop; featherbedding; jurisdictional disputes; and problems of bargaining structure. Individual research is required.

**580 Administrative Tribunals**
An examination of the law controlling administrative agencies, including executive departments, in their tasks of carrying out various governmental programs. One important focus is on procedural safeguards and on the allocation and control of power in decision making. Another central inquiry is how to accommodate procedural fairness to the efficient accomplishment of legislative purposes. The general quest is for understanding principles of exertion of govermental authority and principles of justice that cut across functions of federal, state, and local tribunals and their relation with reviewing courts and with legislative and executive bodies.

**581 Black Labor: Directed Research in the History of the Black Worker**
Students will have access to the complete records of the President's Committee on Fair Employment Practice 1941-1946. These documents, which will be on microfilm, include correspondence, instructions, press releases, internal memoranda, reports from the field, case records, letters from black workers and their organizations describing their situations and conditions, minutes of meetings, and other reports and studies. Emphasis will be placed on a survey and analysis of the existing literature concerning the history of the black worker, a survey and analysis of the literature dealing with the President's Committee on Fair Employment Practice, and student research in the original documents of the Committee.

**600 Seminar in Labor Relations Law and Legislation**
An intensive study of controversial aspects of labor

relations law and legislation in the United States, with concentration on questions of special interest because of their impact on public opinion as well as on labor-management relations. Problems that may be analyzed include national emergency disputes; legal aspects of labor relations in the public sector; remedies for violations of section 8(a)(3) and (5) of the NLRA; common situs picketing; enforcement of arbitration clauses and awards; the duty to bargain about subcontracting and plant removal; problems arising from multiemployer bargaining; regulation of labor relations in agriculture; a union's duty of fair representation; discrimination on the basis of sex and race under Title VII of the Civil Rights Act of 1964.

**601 Collective Bargaining**
An analysis with particular emphasis upon the negotiation process, contract issues of current and future significance, and student research papers.

**602 Problems in Labor Law**
Intensive analysis of selected groups of legal problems arising out of labor relations and arbitrations, based on documentary materials including briefs, minutes, and court and agency proceedings. Weekly or biweekly written reports.

**603 Governmental Adjustment of Labor Disputes**
A study of particular problems of the role of the government in the adjustment of labor disputes in the public and the private sector. Opportunity is afforded to investigate and analyze the various common dispute-settlement techniques and to investigate particular governmental agencies and their operations.

**605 Research Seminar in the History, Administration, and Theories of Industrial Relations in the United States**
Intensive studies in theories of industrial relations, the social and political history of workers in urbanizing and industrializing communities, the history of ideas which impelled the labor movement, the history and government of individual unions and confederations of unions, the development of ideas in the management of personnel, and comparative studies of American, European, and non-European industrial relations systems. The areas of study will be determined by the instructor offering the seminar.

**606 Labor and Government from the 1920s to Taft-Hartley**
An historical survey of the pre-New Deal, the New Deal, World War II, and the immediate postwar periods, culminating in the passage of the Taft-Hartley Act. The course will trace the development and explore the nature and effect of government policy on labor welfare and labor relations legislation. Students will each select a specific event or problem for intensive research on which they will report to the class and prepare a paper.

**607 Collective Bargaining in Public Education**
The seminar will study the legal, financial, administrative, and educational problems raised by collective bargaining in the public schools. Major attention will be directed at existing statutes covering the employment arrangement in public schools, the subject matter and administration of collective agreements, the ideological postures of teacher organizations, and the resolution of negotiating impasses. Individual and group research projects will be required.

**608 Problems of Labor Relations in Public Employment (Law 523)**
A study of the legal problems inherent in the superimposition of collective bargaining relationships on existing patterns of public employment, including the problems of sovereignty, unit determination, representation procedures, unfair practices, scope of bargaining, impasse procedures, and the strike against government. Also includes an examination of civil service systems, government budgeting, restrictions on political activities of public employees (e.g., Hatch Act), loyalty oaths and security programs, and other problems peculiar to public employment.

**609 Professionals, White-Collar Workers, and Their Organizations**
Attention will be directed to characteristics of professional and clerical workers in the white-collar section of the work force. The problems of professionals, both self-employed and salaried, will be considered. A variety of professional organizations and of trade unions will be studied as responses to the collective needs of both groups. Distinctions arising from the conditions of public and private employment will be considered.

**680 Research Seminar in the History of Labor in the Nineteenth Century**
A seminar in the social history of the nineteenth century devoted to the study of workers in urbanizing and industrializing communities. Research ventures will extend across the various fields of history, combining traditional labor history with aspects of urban and business history.

**699 Directed Studies**
For individual research under the direction of a member of the faculty.

## Economic and Social Statistics

**510 Economic and Social Statistics**
A nonmathematical course for students in the social studies without previous training in statistical method. Emphasis is placed on discussion of technical aspects of statistical analysis and on initiative in selecting and applying statistical methods to research problems. The subjects ordinarily covered include analysis of frequency distributions, regression and correlation analysis, and topics from the area of statistical inference.

**610 Economic and Social Statistics**
Primarily a study of the basic concepts underlying quantification in economics and an examination of how these requirements are realized in practice. Intended to familiarize students with the tools used to analyze the labor force, employment, unemployment, production, productivity, labor costs, prices, capital stocks, etc.; determine what they mean; their proper areas of application; and their limitations. Topics in the methodology of economic statistics, including time series analysis and index number problems, will be reviewed.

**614 Theory of Sampling**
A companion course to 310, stressing the development of the fundamentals of sampling theory. Attention will be paid to recent progress in the field. Occasional illustrations of the application of the theory will be given.

**699 Directed Studies**
For individual research under the direction of a member of the faculty.

## International and Comparative Labor Relations

**530 Comparative Industrial Relations Systems I**
An introductory course concerned with the history, structure, institutional arrangements, and philosophy of the labor relations systems of several countries in advanced stages of industrialization, including Great

Britain, France, Germany, Sweden, the Soviet Union, and others.

**531 Comparative Industrial Relations Systems II**
A comparative review of labor problems in countries in early and intermediate stages of economic development. The course surveys the development of the industrial labor force, the evolution of functions of labor organizations, the role of government in industrial relations, the emergence of different patterns of labor-management relations, and problems of employment and wages in relation to economic growth.

**630 Seminar in International and Comparative Labor Problems**
Students will examine selected problems in the light of international and comparative experience and will be expected to prepare, discuss, and defend individual research papers. Topics will vary from year to year in line with student and faculty interests.

**699 Directed Studies**
For individual research under the direction of a member of the faculty.

## Labor Economics and Income Security

**540 Labor Economics**
Economic issues in the employment and compensation of labor. Topics include labor force growth and composition, structure and functioning of labor markets, unemployment, wage theories, wage levels and structures, the economic influence of unions, income distribution, the problem of poverty. Required of graduate students majoring or minoring in labor economics and income security and M.I.L.R. candidates.

**544 Social Security and Protective Labor Legislation**
The fundamental aspects of employee protection and income security. Emphasis will be placed upon state and federal minimum wage and hour laws, antidiscrimination legislation, laws affecting migratory agricultural labor, employee benefit programs. The underlying causes of the legislation, as well as the legislative history, the administrative problems and procedures, and the social and economic impact of the legislation, will be studied. Proposals for amending or modifying existing legislation, including proposals for guaranteed income programs, will be examined. Normally required of graduate students majoring or minoring in labor economics and income security and required of M.I.L.R. candidates.

**546 Economics of Manpower**
Analysis and examination of various approaches to manpower planning. Topics covered include labor force development and behavior, occupational choice and occupational mobility, human capital formation, determinants of occupational employment, and manpower planning and its relation to economic growth in the U.S. and abroad. Methodologies of projecting and of evaluating manpower programs are systematically covered and special topics are developed in accordance with student interests.

**547 Seminar on Investment in Man**
The seminar will cover activities which influence future monetary and psychic income by improving the resources in people. The investments covered include schooling, on-the-job training, medical care, migration, and the search for information on prices and incomes—with main emphasis on education and health. A last section covers educational planning.

**549 Economics of Poverty**
The focus of the course is on the causes of and remedies for income inequalities in industrialized economies. It will concentrate first on alternative theories of inequality in the functional distribution of income—monopolies, rents and quasi-rents, ability, and the acquisition of human capital. The course will then turn to an examination of the relative efficiency of alternative means for remedying these inequalities—countervailing power, taxation, and redistribution of social service.

**645 Comparative Economic Systems: Soviet Russia**
Preparation and discussion of individual papers on selected topics concerning the Soviet economy.

**647 Workshop in Labor Economics**
For Ph.D. students writing their dissertations. The primary concern is with the formulation, design, and execution of dissertations. Preliminary plans and portions of completed work will be presented to the workshop for discussion.

**648, 649 Seminar in Labor Economics (Economics 641, 642)**
Reading and discussion of selected topics in current labor economics in the fields of theory, institutions, and policy.

**699 Directed Studies**
For individual research under the direction of a member of the faculty.

## Manpower Studies

**550 Manpower and Collective Bargaining Problems in the Construction Industry**
The seminar will examine selected manpower and collective bargaining problems in the construction industry, such as supply and demand of construction manpower, the Negro and the building trades, skilled manpower forecasting and planning, skill requirements, education and training, personnel management policies and practices, the wage-price issue, the closed shop, featherbedding, jurisdictional disputes, and problems of bargaining structure. Individual research is required.

**560 Manpower and Organization Management**
A basic graduate course covering the major areas of manpower and organizational policy as they relate to human behavior and work organizations. Intensive consideration will be given to such aspects of personnel work as selection and placement, compensation, training and development, employee-employer relations, health and safety, employee benefits and services, and personnel research. The course will examine how the conduct of the personnel function affects attainment of all organizational objectives. Personnel and industrial relations occupations will also be examined in terms of their career patterns and organizational role.

**561 Occupational Aspects of Manpower Studies**
First, this course examines the job analysis process and its conventional contributions to various personnel activities. Next it examines professional and organizational careers, especially with an eye to their accessibility and adaptability to poor, undereducated, and otherwise disadvantaged people. Finally, it includes individual student projects which consist of preparing job descriptions of various career stages of one high-talent occupation, beginning with the least demanding and ending with the most demanding. These projects will be examined by outside manpower experts in the appropriate specialty.

**562 Administrative Theory and Practice**
A general survey of the theory and practice of administration. Attention focuses on organizational differentiation and its implication to managerial practices. Taught

around cases and field studies. Topics include: theories and approaches to administration, organizational diagnosis, managerial practices, and organizational dynamics.

**564 Public Policy and Development of Human Resources**
Analysis of the need for development of human resources, trends in work force requirements and implications for public policy, the role of government and of educational institutions in providing development programs, and the effectiveness of such programs. Examination of the rationale, organization, and administration of specific programs, such as apprenticeship; vocational and technical schools; technical institutes; university programs for development of technical, scientific, and managerial skills; and the foreign technical assistance program. Implications and problems of public support.

**566 Administration of Compensation**
The development and administration of wage and salary programs with major emphasis on internal considerations. Subjects include program principles, objectives, and policies; organization of the function; and procedures to implement policies. Topics include job and position analysis; preparation of description-specifications; job evaluation; incentive applications; wage and salary structures; the use of wage surveys; supplemental payments, including premium pay, bonuses, commissions, and deferred compensation plans; and use of automatic increment provisions. Case studies and assigned projects will cover selected programs.

**567 Management and Leadership Development**
Study of the factors affecting development of managers and leaders in industrial and other organizations. Consideration is given to organizational environment, formal and informal developmental programs, leadership theory, and individual attitudes and beliefs. Special emphasis is given to analysis of specific case studies of actual practice.

**568 Case Studies in Personnel Administration**
A seminar devoted to analysis of personnel management activities and their impact on organizational objectives and administration. Cases, incidents, and field data from a variety of institutional settings will provide a framework for examining the various roles played by personnel managers. When appropriate, attention will be given to the evolution and formalization of personnel activities within growing small businesses. Field work and preparation of individual cases for class presentation are required.

**569 Design and Administration of Training Programs**
The development of training programs in government, business, labor, and voluntary organizations. Attention will be given to the role of line and staff and to problems and techniques in policy determination, identification of training needs, and design, implementation, and evaluation of programs. Case studies will focus on philosophy and administration of selected programs.

**660 Manpower and Organization Management**
A seminar in which intensive study will center in one or two specific areas of manpower and organization management. Topics will be selected jointly by student and instructor; e.g., manpower planning and forecasting, compensation, justice processes, training and development, and other organizational manpower processes. Individual or group research may also focus on external influences or organizational manpower policies, practices, and strategies.

**661 Alternative Approaches to Manpower Planning**
The seminar will begin with an examination of the rationale for manpower planning and explore the relationships between such planning and educational and economic planning. Major attention will then be directed to alternative approaches to manpower planning: a) the manpower requirement approach, b) the rate-of-return approach, and c) a programming approach combining the previous two. Applications to developing and developed countries will be examined. An individual research paper will be required. A sound grounding in statistics and mathematics is desirable.

**662 Simulation Workshops and Management Training**
The seminar will be conducted through the technique of simulation applied to a rehabilitation workshop. Although the substantive material relates to workshop management, simulation as an approach to training managers has wide and growing importance. The key factor in workshop simulation is the high degree of involvement of participants in setting goals and identifying problems and possible solutions. The seminar focuses on major problem areas in the organization and administration of sheltered workshops. Students are provided with realistic problem-solving situations. A variety of manpower aspects of the management process and the dynamic changes which occur in organizations will be considered. The content of the seminar will be research findings, selected readings, and lectures.

**667 Current Issues and Research in Human Resources Development**
A seminar dealing with development of managerial and work-force skills (particular emphasis to be determined with the group). Papers and class discussions might concentrate on such topics as management development, impact of technological change on training programs, development of scientific and professional personnel, or labor union education.

**699 Directed Studies**
For individual research under the direction of a member of the faculty.

## Organizational Behavior

Graduate students majoring or minoring in the area of organizational behavior will normally complete the core offering in this area, Organizational Behavior I and II (520, 521). Both courses may be taken in the same term, or they may be taken in different terms with either course preceding the other. In addition, graduate students majoring in organizational behavior will normally take Behavioral Research Theory, Strategy, and Methods I and II (524-525) and an appropriate statistics course. Further details on Ph.D. requirements are included in the Department's annual brochure.

**520 Organizational Behavior I**
Survey of concepts and studies from the fields of individual and social psychology, selected for their pertinence to the area of organizational behavior. The relationship between research findings and application to organizational problems will be stressed. Consideration of individual differences; attitude formation and its relation to social processes; factors affecting different kinds of learning; motivation and its relationship to productivity; perception and its relationship to evaluation of performance; leadership and the influence process; group formation and its effect on the individual and the organization.

**521 Organizational Behavior II**
Formal organizations studied from the perspectives of classical organization theory, human relations theory, and comparative and cross-cultural analysis. Contemporary theories and quantitative approaches to organizational structure. This basic course is intended to be

preliminary to more intensive work in organizational behavior.

**522 Theories of Organization**
For students interested in more intensive work in theories of organizations and organizational behavior. Writings examined may include works of the intellectual predecessors of the field, Marx, Weber, and Durkheim, and contemporary works such as those of Homans, Blau, Caplow, Barnard, March and Simon, Etzioni, Crozier, and Dahrendorf.

**523 Theories and Methods of Organizational Change**
The primary concern will be an examination of certain change agents as they attempt to initiate, structure, and direct organizational change. Attention will be given to the strategies used by these change agents as related to selected theories of organizational behavior and organizational change. Among the change agents to be considered are consultants, union organizers, applied social scientists, and staff and managerial personnel.

**524-525 Behavioral Research Theory, Strategy, and Methods I and II**
Units of material include theoretical, conceptual, and ethical questions; survey research and attitude scaling procedures; laboratory research methods; participant observation and interview methods; and the use of documents and qualitative data analysis. The course will provide important philosophical background for doing research and expose the student to a well-balanced, interdisciplinary set of quantitative and qualitative research tools. Readings will be supplemented by projects and laboratory exercises. Designed for candidates majoring in organizational behavior, but other graduate students may enroll.

**526 Management of Science**
The course treats the management of science on both the micro- and macro-levels. It will examine empirical findings as they bear on national policy and environmental settings. Emphasis will be placed on current problems such as freedom and control of science, scientific secrecy, bureaucracy and creativity, financial and political underpinnings of research, and the emerging social system of science.

**527 The Organization and Its Environment**
A survey of the literature on organization-environment and interorganizational relationships. Emphasis is on two tasks: developing typologies of interorganizational relations, and exploring methods of measuring or quantifying such relations. Students will write a research paper applying an organization-environment or inter-organizational perspective to a particular set of organizations.

**528 Psychology of Industrial Conflict**
An application of frustration theory to the analysis of conflict and stress in organizations and society. Comparisons are made among industrial relations, race relations, international relations, and other settings. Readings include behavioral research findings from a variety of studies in industry and contributions from experimental, social, and clinical psychology.

**529 Seminar in Industrial Society**
A research-oriented seminar on selected topics in the study of industrial society. Discussion and critical evaluation of current journal articles, theoretical work, and research dealing with such topics as the organization and stratification, power and organizations, cross-cultural studies, and interorganizational relations.

**571 Individual Differences and Organizational Behavior**
A substantive analysis of the accumulated research evidence on the relationship of human ability, aptitude, and interest patterns to significant criteria of organizational effectiveness. Such variables as intelligence, task expertise, motor skills, clerical skills, cognitive styles, interaction potential, and vocational interest profiles will be emphasized. A variety of occupational categories and organizational settings will be included. Racial and age variables also will be considered.

**572 Organizational Behavior III**
A team-taught comparison of different disciplinary approaches to organizational analysis and models. Emphasis on integrating different disciplinary approaches to selected organizational phenomena such as change and innovation, decision-making and information processing, reward structures, conflict resolution and others.

**620 Seminar on Personality and Organization**
This seminar attempts to integrate available research and focuses on both personality and organizational variables. Investigations in the field of culture and personality will be examined for their utility in the understanding of organizational functioning. The relationship of personality to economic development will also be examined. Participants will be encouraged to write a term paper on the interrelationship of technology and values.

**622 Cross-Cultural Studies of Work and Institutional Development**
A research seminar devoted to the analysis of survey and anthropological field reports from Peruvian villages, industrial plants, and schools, and from comparable United States organizations. Each student will select a problem area for analysis and will write a research paper.

**624 Leadership in Organizations**
A seminar designed to examine theories and research findings from the behavioral sciences that are relevant to leadership and the influence process in groups and organizations. Personality, situational factors, intragroup processes, interpersonal perception, as well as motivation to lead and to follow, will be discussed. The implications for leadership training, organization development, and action research will be explored.

**626 Proseminar in Organizational Behavior**
A research-oriented proseminar on selected topics in organizational behavior. Discussion and critical evaluation of current journal articles dealing with such topics as motivation and work, leadership, individual differences, cognitive styles, interpersonal bargaining, cross-cultural studies, and organizational change.

**629 Cross-Cultural Studies of Organizational Behavior**
The seminar will deal with cross-cultural similarities and differences in organizational processes, e.g., recruitment, decision making, authority, reward, and punishment. Organizations in all sectors of society will be considered; economic, political, educational, health, etc.

**699 Directed Studies**
For individual research conducted under the direction of a member of the faculty.

**Sociology 503 Sociology of Science**
Examination of the relationships between the scientist and sooiety, and of the effects of the scientist on society and of society on the scientist.

## International Agricultural Development

**600 Seminar: International Agricultural Development**
Primarily for graduate students interested in an integrated view of problems related to international agricultural development. The seminar will focus on developing an understanding of the nature and interrelatedness of the social sciences, plant and animal sciences, foods and nutrition, and natural resources to agricultural development.

**601 Philippine Agricultural Development: Policy and Administration**
Major aspects of Philippine agricultural development considered from economic, social, and technological points of view.

**Agricultural Economics 150 Economics of Agricultural Geography**

**Agricultural Economics 452 Regional Agricultural Studies**

**Agricultural Economics 464 Economics of Agricultural Development**

**Agricultural Economics 560 World Food Economics**

**Agricultural Economics 651 Seminar on Agricultural Policy**

**Agricultural Economics 665 Seminar on Latin American Agricultural Policy**

**Agricultural Economics 668 Seminar in the Economics of Agricultural Development**

**Agricultural Economics 669 Seminar in Agriculture and Economic Planning Models**

**Agronomy 301 Identification, Appraisal, and Geography of Soils**

**Agronomy 331 Tropical Meteorology**

**Agronomy 401 Geography and Appraisal of Soils of the Tropics**

**Agronomy 405 Soil Mineralogy**

**Agronomy 422 Tropical Agriculture**

**Agronomy 481 Special Studies in Soils of the Tropics**

**Agronomy 514 Grasslands and Grassland Research**

**Agronomy 522 Special Studies in Tropical Agriculture**

**Animal Science 400 Livestock Production in Warm Climates**

**Animal Science 401 Special Studies on Problems of Livestock Production in the Tropics**

**Animal Science 403 Forages of the Tropics for Livestock Production**

**Communication Arts 501 International Communication**

**Communication Arts 524 Communication in Developing Nations**

**Communication Arts 526 Comparative Mass Media**

**Conservation 511 International Natural Resources**

**Education 524 Designing Extension and Continuing Education Programs**

**Education 525 Educational Communication with Adult Audiences**

**Education 532 Advanced Methods and Materials of Teaching Agriculture**

**Education 627 Seminar: Behavioral Change in International Rural Modernization**

**Food Science 403 International Food Development**

**Food Science 507 High Protein Food Technology**

**Nutrition 580 International Nutrition Problems, Policy, and Programs**

**Plant Breeding 506 International Crop Breeding and Improvement**

**Plant Pathology 655 Plant Diseases in Tropical Agricultural Development**

**Pomology 301 Economic Fruits of the World**

**Rural Sociology 411 Community and Regional Development and Planned Change**

**Rural Sociology 412 Rural Society**

**Rural Sociology 420 Comparative Rural Societies**

**Rural Sociology 424 Occupations and Social Issues**

**Rural Sociology 516 Macrosocial Research and Accounting Methods**

**Rural Sociology 528 Applications of Sociology to Development Programs**

**Rural Sociology 631 Seminar: Contemporary Social Theory II**

**Rural Sociology 636 Seminar: Social Change and Development**

**Vegetable Crops 429 Special Topics in Plant Science Extension**

**Vegetable Crops 501 Research Methods in Applied Plant Science**

## Latin American Studies

**Agricultural Economics 665 Seminar on Latin American Agricultural Policy**

**Agricultural Economics 668 Seminar in the Economics of Agricultural Development**

**Agronomy 401 Geography and Appraisal of Soils in the Tropics**

**Agronomy 480 Management Systems for Tropical Soils**

**Animal Science 400 Livestock Production in Warm Climates**

**Animal Science 401 Special Studies on Problems of Livestock Production in the Tropics**

**Animal Science 403 Forages of the Tropics for Livestock Production**

**Anthropology 332 Ethnology of South America**

**Anthropology 333 Ethnology of the Andean Region**

**Anthropology 350 Comparative Civilizations**

**Anthropology 354 Archaeology of the Americas I**

**Anthropology 355 Archaeology of the Americas II**

**Anthropology 356 Mesoamerican Thought and Culture**

**Anthropology 418 Ethnohistory**

**Anthropology 532 Tribal People**

**Anthropology 533 Andean Research**

**Consumer Economics and Public Policy 345 International Housing Problems and Policies**

**Development Sociology 420 Comparative Rural Societies**

**Development Sociology 516 Cross-Cultural Research Methods**

**Development Sociology 528 Applications of Sociology to Development Programs**

**Economics 325/525 Economic History of Latin America**

**Economic 565 Economic Problems of Latin America**

**Government 337 Imperialism**

**Government 340 Government and Politics of Latin America**

**Government 578 Research Seminar on the U.S. Presence in Latin America**

**History 319 The Colonial Experience in Latin America**

**History 320 Latin American History in the Nineteenth and Twentieth Centuries**

**History 487 Seminar in Slavery and Abolition in the Americas**

**History 488 Seminar in the History of Brazil**

**History 489 Seminar in Latin American History**

**History 687 Seminar in Latin American History**

**History 688 Seminar in Latin American History**

**History of Art 315 Pre-Columbian Art**

**History of Art 392 Latin American Art**

**History of Art 415 Seminar in Pre-Columbian Art**

**History of Art 510 Seminar in Latin American Art**

**Industrial and Labor Relations 622 Cross-Cultural Studies of Work and Institutional Development**

**Linguistics 515-516 Sociolinguistics**

**Sociology 320 Population Problems**

**Sociology 367 After the Revolution: Mexico and Cuba**

**Sociology 434 Sociology of Human Fertility**

**Sociology 530 Introduction to Social Demography**

**Spanish 105 Permanence and Revolution in Twentieth-Century Spanish American Prose Fiction**

**Spanish 334 Spanish American Short Story**

**Spanish 392 Modern Spanish American Poetry**

**Spanish 401 History of the Spanish Language**

**Spanish 403 The Grammatical Structure of Spanish**

**Spanish 426 Spanish American Literature from Discovery to Independence**

**Spanish 501 Linguistic Structures of Ibero-Romance**

**Spanish 503 Hispanic Dialectology**

**Spanish 536 Graduate Seminar in Spanish American Literature: Carpentier**

**Spanish 600 Seminar in Ibero-Romance Linguistics**

## Law

The courses offered in the Law School are all open to LL.M. and J.S.D. candidates. Reference should be made to the *Announcement of the Law School* for detailed course descriptions.

## Linguistics

**207 Practical Phonetics**

**301-302 The Structure of English**

**303 Phonology**

**304 Morphology**

**306 Syntax**

**331 India as a Linguistic Area**

**401 Language Structures**

**403-404 Analytic Techniques**
A practical training course in the techniques of observation and analysis of descriptive linguistics.

**406 Dialectology**
A general survey of the study of dialectal variations in language and the various methodological problems found in European and non-European languages.

**413-414 Linguistic Data Processing**
A brief survey of general computer design and techniques and elementary training in SNOBOL stressing character manipulation. Attention will be given to the computability of linguistic problems, and students will be expected to devise solutions to problems from their own data.

**432 Indo-Aryan Structures**
A synchronic examination of the phonological and grammatical structures of major Indo-Aryan languages. Typological studies in the languages of the family.

**436 Dravidian Structures**
A synchronic examination of the phonological and grammatical structures of the major languages of the family. Typological studies in Dravidian languages.

**502 Comparative Methodology**
A study of the methods and techniques in comparative linguistics; application of these methods in various language families depending on the student's background.

**504 History of Linguistics**

**505 Literature, Language, and Culture**
A survey of the relation of literature to its linguistic medium and cultural matrix.

**506 Pidgin and Creole Languages**
A survey of the field of pidginized and creolized languages, with discussion of methodological problems, historical relationships, and reading of selected texts.

**507-508 Field Methods and Linguistic Typology**

**511-512 Acoustical Phonetics**
A rapid survey of the techniques of experimental articulatory phonetics; the speech mechanism as a sound generator; sound spectrography, psycho-physiology of hearing; application of acoustical analysis to the study of speech sounds. Requires no mathematical training beyond arithmetical computation.

**513-514 Transformational Analysis**
An introduction to the theory, literature, and practice.

**515-516 Sociolinguistics**

**521-522 Comparative Indo-European Linguistics**
A comparative study of the phonology and morphology of the Indo-European languages and of their interrelationships.

**530 Elementary Pali**

**531-532 Elementary Sanskrit**

**534 Comparative Indo-Aryan**
Comparative reconstruction of proto-Indo-Aryan phonology and grammar.

**536 Comparative Dravidian**
Comparative reconstruction of proto-Dravidian phonology and grammar.

**537-538 Old Javanese**

**561-562 Comparative Slavic Linguistics**

**571-572 Seminar in Southeast Asian Linguistics**
Descriptive and comparative studies of mainland Southeast Asian languages are dealt with in alternate terms. Topics may be selected in accordance with the interests of the students.

**573-574 Malayo-Polynesian Linguistics**

**577 Thai Dialectology**

**578 Comparative Thai**

**579 Thai-Burmese Linguistics**

**582 Sino-Tibetan Linguistics**
Descriptive and comparative studies of Chinese dialects and Tibeto-Burman languages.

**583 Contrastive Vietnamese and Chinese Grammar**

**600 Seminar**
Subject to the needs of students and to the limitations of staff time, advanced seminars are set up a wide variety of topics, which, in the past, have included the following: contemporary grammatical theory, applied linguistics in language teaching, applied linguistics in literary training and orthography formation, English grammar, German dialects, Romance-based creoles, discourse theory.

**Chinese 401-402 History of the Chinese Language**

**Chinese 403 Linguistic Structure of Chinese: Phonology and Morphology**

**Chinese 404 Linguistic Structure of Chinese: Syntax**

**Chinese 405 Chinese Dialects**

**Chinese 507 Chinese Dialect Seminar**

**Hindi 401 History of Hindi**

**Hindi 600 Seminar in Hindi Linguistics**

**Indonesian 403 Linguistic Structure of Indonesian**

**Japanese 404 Linguistic Structure of Japanese**

**Quechua 600 Seminar in Quechua Linguistics**

**Tagalog 403 Linguistic Structure of Tagalog**

See also Anthropology 520; Classics (Classical Linguistics) 421-422, 423, 424, 425, 426; English Language and Literature 383, 501, 503, 510; Germanic Studies 401-402, 403, 501, 502, 503-504, 509-510, 651-652; Human Development and Family Studies 623; Philosophy 590, 595; Psychology 313, 416; Romance Linguistics: French 401-402, 403, 554, 555, 558, 600; Italian 431, 432, 433, 434; Romance Linguistics 441-442, 443-444, 445, 446, 449; Spanish 401, 402, 403, 501, 502, 503, 504, 600; Slavic Studies 401-402, 403, 501, 502, 600, 603, 611.

# Materials Science and Engineering

**6601 Topics in Thermodynamics and Kinetics**
Generalization of thermodynamics to include non-chemical forms of energy. Statistical nature of entropy. Phase stability. Defect equilibria. Thermodynamics of solutions, surfaces, and interfaces. Reaction kinetics. Diffusion. At the level of Slater, *Introduction to Chemical Physics;* Guggenheim, *Thermodynamics.*

**6602 Phase Transformations**
Interfaces between phases. Nucleation theory. Growth theory. Formal theory of nucleation and growth transformations. Spinodal decomposition. Diffusionless transformations. Applications of the theory to specific changes in real materials. At the level of Christian, *Theory of Phase Transformations in Metals and Alloys.*

**6603 Crystal Mechanics**
Crystal symmetry. Vector fields and tensor fields. Lattice deformation and fault crystallography. Reversible tensor properties of crystals. Relationships between different tensor properties. Crystal elasticity, elastic waves, and polymer elasticity. Lattice dynamics. Thermophysical properties. Irreversible tensor properties. Coupling of transport phenomena. Higher order effects. At the level of Nye, *Physical Properties of Crystals;* Born and Huang, *Dynamical Theory of Crystal Lattices;* and Smith, *Wave Mechanics of Crystalline Solids.*

**6604 Dislocations**
Review of geometrical and strain energy aspects of dislocation theory. Experimental evidence for dislocations. Dislocation strain and stress fields and associated strain energy. Interactions with applied stresses and with other dislocations. Jogs, point defects, and climb. Dislocation sources. Crystallographic aspects such as stacking faults and partial dislocations in specified crystal structures. Grain boundaries. At the level of Hirth and Lothe, *Theory of Dislocations* and Nabarro, *Theory of Crystal Dislocations.*

**6605 Electrical and Magnetic Properties of Engineering Materials**
Electrical properties of semiconductors. Metallic alloys. Ferromagnetic materials. Superconductivity. Optical and dielectric properties of insulators and semiconductors. Ferrites. At the level of Kittel, *Introduction to Solid State Physics;* Chikazumi, *Physics of Magnetism;* Livingston and Schadler, *The Effect of Metallurgical Variables on Superconductivity Properties;* de Gennes, *Superconductivity of Metals and Alloys.*

**6606 Mechanical Behavior of Materials**
Geometry of slip in single crystals. Strain hardening. Dislocation dynamical treatment of yield and flow. Interaction of interstitial solute atoms with dislocations. Solution hardening. Two-phase hardening. Time-dependent deformation. Dislocation models for cleavage of crystals. At the level of review articles in *Progress in Materials Science* and various conference reports.

**6611 Principles of Diffraction (Applied Physics 8211)**
A broad introduction to diffraction phenomena applied to solid-state problems. Production of neutrons and x rays. Scattering and absorption of neutrons, electrons, and x-ray beams. Diffraction from two- and three-dimensional periodic lattices. Crystal symmetry. Fourier representation of scattering centers and the effect of thermal vibrations on scattering. Phonon information from diffuse x-ray and neutron scattering as well as Bragg reflections. Standard crystallographic techniques for single crystals and powders. Diffraction from almost periodic structures, surface layers, gases and amorphous materials. A survey of dynamical diffraction from perfect and imperfect lattices. Techniques for imaging structural defects. Selected experiments illustrating diffraction effects.

**6553-6554 Project**
Research on a specific problem in materials or metallurgical engineering, applicable to the M.Eng.(Materials) degree.

**6612 Selected Topics in Diffraction (Applied Physics 8212)**
The Ewald-von Laue dynamical theory applied to x-ray and high energy electron diffraction in solids. Thermal scattering and measurement of phonon dispersion, frequency spectrum, interatomic force constants, Debye temperatures and vibrational amplitudes. Diffuse scattering, short- and long-range order, precipitation in solids, point defects.

**6762 Physics of Solid Surfaces (Applied Physics 8262)**
Equilibrium thermodynamics and statistical mechanics of interfaces. Diffuse interfaces, crystal surfaces, anisotropy and orientation dependence of surface properties, Wulff diagrams. Atomic structure of surfaces in equilibrium. Surface fields, dipoles and defects in insulators. Electronic and vibrational properties of surfaces. Surface barriers and work functions, surface vibrational and electronic states. Kinetic processes at surfaces. Mass and charge transport in the surface region. Condensation and evaporation processes. Experimental techniques: discussion of LEED, FIM, FEM, etc. Materials drawn from research papers and various review articles such as *Progress in Materials Science, Advances in Chemistry, Solid State Physics,* and specialized texts such as Many, Goldstein, and Grover, *Semiconductor Surfaces,* and Kaminsky, *Atomic and Ionic Impact Phenomena.*

**6764 Fracture of Materials**
Mechanics of fracture. Griffith theory. Crack tip stresses and strains. Crack tip plasticity. Macroscopic aspects of fracture in crystalline and noncrystalline materials. Dislocation models. Void growth. Special topics such as fatigue, environment and fracture, fracture testing. Materials from conference reports; Tetelman and McEvily, *Fracture of Structural Materials;* Kelly, *Strong Solids.*

**6765 Amorphous and Semicrystalline Materials**
Topics selected from the following general areas: structure of liquids and polymers; rheology of elastomers and glasses; electrical, thermal, and optical properties of amorphous materials. At the level of Mackenzie, *Modern Aspects of the Vitreous State;* Treloar, *The Physics of Rubber Elasticity;* Shen and Eisenberg, *Glass Transition in Polymers.*

**6873 Materials Science for Engineers**
Structure of crystals. Crystal lattice properties. Crystal defects (point, line, planar). Thermodynamics of solids. Diffusion and kinetics (emphasis on defect annealing, e.g., polygonization, recrystallization, grain growth, point defect recovery, etc.). Mechanical properties (role of crystal defects in plastic deformation, creep, fracture). Topics in radiation damage including defect productions, radiation damage annealing, and effect of damage on physical properties.

# Mathematics

## Applied Mathematics and Differential Equations

**315 Higher Calculus**
Vector analysis. Ordinary and partial differential equations. Fourier series. Special functions. Laplace transforms. Emphasis is placed on a wide range of formal applications of the calculus rather than on the logical development.

**415-416 Mathematical Methods in Physics**
Lectures and problems designed to give a working knowledge of the principal mathematical methods used in advanced physics. Topics include a brief discussion of some basic notions: metric space, vector space, linearity, continuity, integration. Generalized functions (Schwartz distributions). Fourier series and Fourier integrals. Elementary complex variable. Saddle point method. Linear transformations in finite- and infinite-dimensional spaces. Matrices. Differential operators and integral operators, the equations and eigenvalue problems connected with them, and the special functions arising from them. Elements of groups theory. The rotation groups and its representations.

**421 Applicable Mathematics**
Theorems of Stokes, Green, Gauss. Sequences and infinite series. Fourier series and orthogonal functions. Ordinary and partial differential equations.

**422 Applicable Mathematics**
Complex variables. Generalized functions. Laplace and Fourier transforms. Probability and statistics.

**423 Applicable Mathematics**
Linear operators and integral equations. Calculus of variations. Application to eigenvalue problems. Green's function, and treatment of special problems of mathematical physics.

**427-428 Introduction to Differential Equations**

**517-518 Ordinary Differential Equations**
Existence and uniqueness. Autonomous systems, with specialization in geometric theory in two dimensions. Linear equations. Stability. Bifurcation theory. Some special functions of mathematical physics, from the viewpoint of equations in the complex domain and the two-point-boundary-value problem.

**519-520 Partial Differential Equations**
Classification of partial differential equations. Questions of existence, uniqueness, and continuity of the solutions of typical boundary-value problems. The equations of Laplace and Poisson, principles of the maximum and the mean; the wave equation, heat equation.

**522 Applied Functional Analysis**
Spectral theorem for bounded operators, spectral theory for unbounded operators in Hilbert space, compact operators, distribution. Applications.

**619-620 Advanced Partial Differential Equations**

**627-628 Seminar in Partial Differential Equations**

## Analysis

**411-412 Introduction to Analysis**
An introduction to the theory of functions of real variables, stressing rigorous logical development of the subject rather than technique of applications. Topics include elementary topology, the real number system, continuous and differentiable functions, integration, convergence and approximation theorems. Fourier series, calculus in several variables and differential forms.

**413 Introduction to the Theory of Functions of One Complex Variable**
A rigorous introduction to complex variable theory. Intended mainly for undergraduates and for graduate students outside mathematics; graduate students in mathematics desiring a first course in complex variables should take 511-512. Complex numbers. Differential and integral calculus for functions of a complex variable including Cauchy's theorem and the calculus of residues.

Elements of conformal mapping. Elements of several complex variables.

**511-512 Real and Complex Analysis**
First term: set-theoretic preliminaries, abstract integration. Borel measures, Lebesgue measures, $L_p$ spaces, Hilbert spaces, Banach spaces, product spaces, differentiation. Second term: Fourier transforms. Complex variables, harmonic functions, Schwarz lemma, approximation by rational functions, conformal mappings, including Riemann mapping theorem, Weierstrass- and Mittag-Leffler theorems, Jensen's formula, analytic continuation, the modular function, Picard's theorem.

**514 Complex Variable Theory**

**515 Potential Theory**
Newtonian as well as logarithmic potential, capacity, Green's functions and the Dirichlet problem in Euclidean space. Either applications to function theory, or integral representation theorems or some probabilistic potential theory.

**523 Analysis on Manifolds**

**528 Variational Methods**

**611-612 Seminar in Analysis**

**613 Functional Analysis**
Topological vector spaces, Banach and Hilbert spaces, Banach algebras. Additional topics to be selected by instructor.

**615 Fourier Analysis**
An introduction to harmonic analysis and group representations via important special cases: Fourier series and integrals in several variables (abelian groups), spherical harmonics (compact groups) and representations of the Lorentz groups (noncompact Lie groups). Emphasis will be on the $L^2$ theory, and distributions.

**617 Analytic Number Theory**

**621 Meromorphic Functions**

**622 Riemann Surfaces**

**623 Several Complex Variables**
An introduction to the theory of functions of several complex variables. Domains of holomorphy, removable singularities, analytic varieties. Stein manifolds.

## Algebra

**431-432 Introduction to Algebra**
A rigorous introduction to modern algebra. First term: linear algebra. Second term: introduction to algebraic systems such as groups, rings, modules, and fields.

**531-532 Algebra**
First term: finite groups, field extensions, Galois theory, rings and algebras, tensor algebra. Second term: Wedderburn structure theorem, Brauer group, group cohomology, Ext, Dedekind domain, primary decomposition, Hilbert basis theorem, local rings. Additional topics selected by instructor.

**549-550 Lie Groups and Differential Geometry**
Differentiable manifolds. Basic properties of Lie groups and their relationship to Lie algebras. Compact Lie groups, maximal tori, the Weyl group. Theory of Lie algebras over the real and complex fields. The classical groups.

**631-632 Seminar in Algebra**

**633 Group Theory**
Representations and characters of finite groups; transfer and induced representations. Applications to structure of finite groups as time permits.

**635 Theory of Rings**

**637 Algebraic Number Theory**
A summary of the algebraic foundations followed by a discussion of some classical problems: class numbers, primes in arithmetic progressions, binary quadratic forms and genera.

**639 Lie Algebras**
Topics in Lie algebras.

**641 Homological Algebra**

**649 Topological Groups**

## Geometry and Topology

**451-452 Classical Geometries**
Axiomatic methods in geometry. Foundations of Euclidean geometry. Non-Euclidean geometry, projective geometry, other geometric theories.

**453-454 Introduction to Topology and Geometry**
Covers topics in general and algebraic topology, differentiable manifolds, and perhaps some differential geometry.

**551 Introductory Algebraic Topology**
The fundamental group and covering spaces. Homology and cohomology theories for complexes and spaces.

**552 Differentiable Manifolds**
Manifolds and differentiable structures. Tangent, cotangent, and tensor bundles. Exterior calculus. Riemannian structures. Local and global theory of differential equations. Integration on manifolds.

**561 Geometric Topology**
Topics from general topology. Introduction to the geometric properties of manifolds.

**651-652 Seminar in Topology**

**653-654 Algebraic Topology**
Duality theory in manifolds, applications, cohomology operations, spectral sequences, homotopy theory, general cohomology theories, categories and functors.

**655-656 Homotopy Theory**

**657-658 Advanced Topology**
A selection of advanced topics from modern algebraic, differential, and geometric topology. Course content varies from year to year.

**659 Symmetric Spaces**

**661-662 Seminar in Geometry**

**663 Manifolds**

**667 Algebraic Geometry**
The theory of algebraic curves. The Riemann-Roch theorem. Projective embeddings. Singularities.

## Probability and Statistics

**472 Statistics**
Classical and recently developed statistical procedures are discussed in a framework which emphasizes the basic principles of statistical inference and the rationale underlying the choice of these procedures in various settings. These settings include problems of estimation, hypothesis testing, and large sample theory.

**473 Statistics**
A continuation of 472 in which emphasis will be placed on experimental designs, nonparametric statistics, multivariate analysis, sequential analysis and multiple decision problems.

**571-572 Probability Theory**
Properties and examples of probability spaces. Sample

space, random variables, and distribution functions. Expectation and moments. Independence, Borel-Cantelli lemma, zero-one law. Convergence of random variables, probability measures and characteristic functions. Laws of large numbers. Selected limit theorems for sums of independent random variables. Markov chains, recurrent events. Ergodic and renewal theorems. Martingale theory. Brownian motion and processes with independent increments.

**571-574 Probability and Statistics**
First term: Same as first term of 571-572. Second term: Topics include an introduction to the theory of point estimation, consistency, efficiency, sufficiency, and the method of maximum likelihood; the classical tests of hypotheses and their power; the theory of confidence intervals; the basic concepts of statistical decision theory; the fundamentals of sequential analysis. Intended to furnish a rigorous introduction to mathematical statistics, the course is prerequisite to all advanced courses in statistics.

**575 Information Theory**
Coding theorems and their converses for the principal noisy channels. Sequential decoding. Two-way codes. Coding with a fidelity criterion. Study of the probability of error. Very recent results on channels with arbitrarily varying channel probability functions and on compound channels.

**671-672 Seminar in Probability and Statistics**

**673 Analysis of Variance**

**674 Design of Experiments**

**675 Statistical Estimation**
Randomization, sufficiency, completeness, minimum variance estimators. Derivation of sequential minimax estimators by the methods of differential inequalities. Bayes solutions, and invariance. The Neyman-Pearson theory of testing hypotheses and interval estimation.

**676 Decision Functions**
Wald's theory of decision functions. Multidecision problems. Existence theorems, complete class theorems, and other general decision theoretic results. Optimum character of the sequential probability ratio test. Recent developments.

**677-678 Stochastic Processes**

**679 Seminar in Mathematical Economics**

## Mathematical Logic

**581 Logic**
Basic topics in mathematical logic including: propositional and predicate calculus; formal number theory and recursive functions; completeness and incompleteness theorems.

**681-682 Seminar in Logic**

**683 Model Theory**

**684 Recursion Theory**
Theory of effectively computable functions. Classification of recursively enumerable sets. Degrees of recursive unsolvability. Applications to logic. Hierarchies. Recursive functions of ordinals and higher type objects. Generalized recursion theory.

**685 Metamathematics**

**687 Set Theory**
Models of set theory. Theorems of Gödel and Cohen, recent independence results.

**690 Supervised Reading and Research**

# Mechanical Engineering

**3090-3091 Mechanical Engineering Design Project**
Intended for students in the M.Eng.(Mech.) program. Design of an engineering system or an advanced device. Projects to be carried out by individual students or by small groups with individual assignments, culminating in an engineering report by each student.

**3361 Advanced Mechanical Analysis**
Intended for students in the M.Eng.(Mech.) program. Advanced topics in mechanical design. Selected topics from design optimization, design reliability, advanced kinematics, systems analysis, computer-aided design, advanced strength of materials.

**3363 Mechanical Components**
Advanced analysis of machine components and structures. Application to design of new configurations and devices. Lubrication theory and bearing design. Fluid couplings, torque converters, speed-control devices. Shell, thick-cylinder, and elastic-foundation theory and design of pressure vessels, rotating disks, and fits. Elastic-plastic design, thermal stresses, creep and relaxation. Impact.

**3364 Design for Manufacture**
Design of castings, forgings, stampings, and weldments; unconventional processes. Design for heat-treatment, machining, and assembly; selection of materials; dimensioning and fits, jigs and fixtures. Joints, fasteners, and shaft mountings and connections. Specifications for manufacture and maintenance to minimize fatigue failures and improve reliability; beneficial prestressing; improving the distribution of loads and deflections. Seals and lubrication systems. Components and circuits for fluid power and controls. Short design problems.

**3365 Biomechanical Systems—Analysis and Design**
Selected topics involving the human body as a mechanical system. Emphasis on the modeling, analysis, and design of biomechanical and man/machine systems frequently encountered in orthopedic surgery and physical rehabilitation. Investigation of normal and impaired biomechanical systems. Analysis and design of assistive (orthotic) and replacement (prosthetic) devices for impaired biomechanical systems.

**3366 Advanced Kinematics**
Advanced analytical and graphical determination of velocities and accelerations in mechanisms. Special geometrical concepts on the kinematics of mechanisms. Synthesis of linkages by graphical and analytical methods. Design of linkages to give prescribed paths, positions, velocities, and accelerations.

**3368 Mechanical Vibrations**
Further development of vibration phenomena in single- and multi-degree-of-freedom linear and nonlinear systems, with emphasis on engineering problems involving analysis and design. Also gyroscopic effects, branched systems, random vibrations, impact and transient phenomena, isolation of shock vibration, and noise and its reduction. Impedance, matrix, and numerical methods. Analog and digital computer solutions and laboratory studies.

**3372 Experimental Methods in Machine Design**
Investigation of methods used to obtain design and performance data. Techniques of photoelasticity, strain measurement, photography, vibrations, and sound measurements, and development techniques are studied as applied to machine design problems.

**3374 Conceptual Design**
A treatment of the processes of advanced system or new product evolution as practiced by industry, includ-

ing product planning, creation of ideas, synthesis into working concepts and evaluation. A working exposure to engineering components. Numerous projects, much discussion, some lectures.

**3377 Automotive Engineering**
A discussion of the important design parameters for motor vehicles and their major components including engine, driveline, brakes, suspension, handling and structure, with emphasis on the influence of design variables on performance and of basic ideas and alternatives. Lectures, discussion, term paper.

**3378 Automatic Control Systems**
Further development of feedback control theory, including stability criteria, frequency response, and transfer functions, with emphasis on engineering problems involving the analysis of existing control systems and the design of systems to perform specified tasks. Also, nonlinear systems, describing functions, sampled-data systems, and compensation techniques. Analog computer simulation and laboratory studies of hydraulic, pneumatic, and electromechanical components and systems.

**3380 Design of Complex Systems**
A seminar course relying heavily on student participation in discussing frontier problems such as systems for space and underwater exploration, salt water conversion, and transportation. Determination of specifications for these systems to meet given needs. Critical discussion of possible solutions based on technical as well as economic and social considerations. Reports will be required containing recommendations and reasoning leading to these considerations.

**3382 Hydrodynamic Lubrication**
Designed to acquaint those having a general knowledge of solid and fluid mechanics with the special problems and literature currently of interest in various fields of hydrodynamic lubrication. General topics include equations of viscous flow in thin films, self-acting and externally pressurized bearings with liquid and gas lubricant films, bearing system dynamics, digital and analog computer solutions. Also selected special topics in elastohydrodynamic, thermohydrodynamic, and magnetohydrodynamic lubrication.

**3385 Optimum Design of Mechanical Systems**
The formulation of design problems frequently encountered in mechanical systems as optimization problems with emphasis on the choice of the design objective function and the constraints. Finite and infinite dimensional design problems. Theory and application of methods of mathematical programming to the solution of optimum design problems. Examples drawn from structures and machine components frequently encountered in mechanical systems.

**3387 Dynamics of Vehicles**
An introduction to the dynamics of automobiles and trucks. Emphasis on the handling behavior of the automobile. Tire theory and suspension analysis, articulated vehicle handling, motorcycle dynamics, and vehicle safety.

**3388 Computer Simulation and Analysis of Dynamic Systems**
Some introductory acquaintance with systems dynamics and digital programming areas is assumed. Modeling and representation of physical systems by systems of ordinary differential equations in vector form. Applications from diverse fields. Simulation diagrams. Analog and digital simulation by direct integration. Problem-oriented digital simulation languages (e.g., CSMP). Digital analysis of stability and response of large linear systems. At the level of Chen and Haas, *Elements of Control System Analysis, Part II* and Conte, *Elementary Numerical Analysis.*

**3451 Analysis of Manufacturing Processes**
Analytical treatments of material removal and plastic deformation processes from the interdisciplinary viewpoints of mechanics, thermodynamics, and metallurgy. Emphasis is placed equally on conventional and unconventional processes involving ultrasonic, high-energy beam, electric-discharge, and electrochemical energy sources. Also economic analysis of production system and machine tool dynamics.

**3475 Introduction to Numerical Control**
A broad introduction to numerical control technology covering both hardware and software aspects. Principles of conventional numerical control systems, adaptive control, and directly computer-controlled machine tools. Manual and computer-aided part programming methods. Extensive exercises in APT programming. Methodology for economic justification.

**3656 Advanced Thermal Engineering Laboratory**
Individually offered experimental studies, ranging from performance testing of engine components to studies of laser interferometry, prepared and supervised by faculty of Thermal Engineering, and elected by students. The time allotted, and number of students accepted will be specified by the instructor for each experiment. List of topics for each term furnished by professor in charge.

**3659 The Nature of Thermodynamics**
A study of the history, philosophy, and mathematics of thermodynamics with emphasis upon its scope and limitations. Consideration of the methods of exposition of the concepts and laws of thermodynamics; comparison of the intuitive, axiomatic, and statistical approaches. The course will be principle- rather than problem-oriented and each student will be expected to develop a special topic in thermodynamics, present it orally, and write a term paper in place of a final examination.

**3663 Turbomachinery**
Aerothermodynamic design of turbomachines in general, followed by consideration of specific types; fans, compressors, and pumps; steam, gas, and hydraulic turbines. Energy transfer between a fluid and a rotor; flow in channels and over blades. Compressible flow, three-dimensional effects, surging and cavitation. Outline design of a high-performance compressor-turbine unit.

**3665 Transport Processes**
Description of modes of thermal and mass diffusion and transport. Formulation of the transport equations and their use in engineering and in environmental studies. Conduction and mass diffusion in solid materials. Thermal radiation exchange among assemblies of radiating bodies and as a diffusion process. Nature of nonopaque radiation interaction. Energy and mass diffusion by molecular and turbulent processes in convection. Regimes of transport. Consideration of convection resulting from buoyancy forces and from other forcing conditions in fluids. Various aspects of buoyancy-induced flows emphasized in relation to applications.

**3667 Physics of Air Pollutants and Their Production**
A fundamental treatment of selected physical and chemical topics pertinent to understanding gaseous air pollution and its control. Topics include: chemical equilibrium, kinetic theory, statistical calculation of thermodynamic properties of gases, spectroscopic determination of atomic and molecular properties, reaction kinetics, heats of reaction, and adiabatic flame temperatures. Examples will be selected to illustrate the production and properties of particular pollutants. The course will provide a basis for advanced work in air pollution, and

related areas such as power and propulsion, high-temperature gas dynamics, and fire research and combustion.

**3668 Flame Dynamics**
A fundamental examination of the fluid mechanics, heat transfer, mass transfer, and reaction kinetics associated with flames. Governing equations are developed and applied to flames of deflagration, detonation, and diffusion types. Ignition, quenching, and turbulence effects are examined. Additional topics include flame stabilization, burning limits, and explosions. Kinetic, thermal, and diffusion control of flames is illustrated with environmental combustion problems such as incomplete burning and nitric-oxide production in power and propulsion systems, and the spread, containment, and steady burning of destructive fires.

**3671 Aerospace Propulsion Systems**
Application of thermodynamics and fluid mechanics to the design and performance of thermal-jet and rocket engines in the atmosphere and in space. Space mission analysis as it affects the propulsion system. Consideration of auxiliary power supply; study of advanced methods of space propulsion.

**3672 Energy Conversion**
Primarily an analysis of energy conversion devices as classified into heat engines, chemical engines, and expansion engines. An analysis of each class from the point of view of efficiency and other criteria of performance. A more detailed study of some conventional and some direct energy conversion devices including thermoelectric, thermionic, and photovoltaic converters; and fuel cells. Energy sources and energy storage, applications to terrestrial and space power systems.

**3674 Flowing Gas Lasers**
A comprehensive treatment of the principles of operation of continuous-wave chemical lasers, fluid-mixing lasers and gasdynamic lasers. Opportunity for experimental laboratory studies of a high-power, purely chemical DF-$CO_2$ laser. Topics covered include: fluid mechanics of the production of population inversions by rapid mixing, chemical reaction, detonation waves, and Prandtl-Meyer expansion; vibrational energy transfer processes in chemical and molecular lasers; chemical kinetics of atom-exchange reactions; chain reaction mechanisms; gain saturation and power output characteristics of high-speed flow lasers; optical design of transverse-axis flow laser resonators; survey of current developments in flowing gas lasers; laser-induced fluorescence spectroscopy.

**3675 Dynamics of Rotating Fluids**
Review of classical fluid mechanics. Rotating coordinate systems. Linearized theory for rapidly rotating fluids. Inviscid regions, viscous layers. Large-amplitude steady motions past objects. Unsteady motions. Small-amplitude waves. Wave motion in anisotropic, dispersive media. Phase and group velocity. Kinematic wave theory and energy propagation. Nonlinear waves in rotating fluids. "Vortex breakdown" in tornados and other swirling flows. Theories of vortex breakdown. Boundary layer interactions. Spin-up of fluids in rotating containers. A theoretical course for engineers and scientists interested in such applications as fluid motions in rotating containers, geophysical fluid mechanics, energy and mass separation in vortex tubes, etc. Some simple laboratory demonstrations of fundamental phenomena are included.

**3676 Applications of Fluid Mechanics**
A descriptive survey of fluid mechanics, organized according to application. Acoustics, flight aerodynamics, aircraft stability and performance, propulsion problems, shocks, detonations and blast waves, hypersonic entry, droplets, oceanography and marine systems, biofluid mechanics, and aspects of meteorology and astrophysics are considered. Midterm and final reports required, treating in depth a topic chosen by the student.

**3677 Numerical Methods in Fluid Flow and Heat Transfer**
Finite-difference and finite-element methods are developed for solving multidimensional fluid flow and heat transfer problems. Basic principles are stressed, enabling the methods to be extended to problems involving chemical reactions, mass diffusion, or variable properties. Physical and numerical restraints imposed on transient and steady-state numerical solutions are determined. Recent methods are surveyed and compared. Selected examples illustrate applications involving natural convection, flow over objects and within channels, planetary atmospheres and interiors, and flame spread. Assigned problems and the final examination require solution of fluid flow problems on a digital computer.

**3679 Inviscid Flow Theory**
Potential theory, including distributions of singularities, transformations, wings and cascades, slender-body theory, compressibility; gasdynamics and supersonic flow, including shocks and expansions, characteristics, blast waves, small disturbance theory; multicomponent flows and stability, including continuous and discontinuous stratification, and the effects of gravity, surface tension, and compressibility on the stability of such flows.

**3680 Convection Heat Transfer**
Processes of the diffusion of thermal energy, mass, and of momentum. Basic equations are reasoned in detail and applied to problems of current importance in technology and in environmental and ecological studies. Natural convection (buoyancy-induced) flows are considered in detail. Convection layers adjacent to surfaces and freely rising plumes, buoyant jets and thermals in extensive media (including stratified) are treated for laminar and for turbulent processes. Transient flows. Conversion of laminar flows, through instability and transition, to turbulence. Thermal instability and resulting flows. Diffusion characteristics in naturally occurring bodies of fluid. Forced flows and resulting convection, including effects of appreciable variation of properties and viscous dissipation. The nature of convection in flow driven jointly by buoyancy forces and by imposed conditions, such as those in the atmosphere and adjacent to heated surfaces; limits and mechanisms of these mixed flows. Emphasis is on analysis, classification of convection regimes, and comparison of the results of analysis with observations.

**3682 Seminar in Heat Transfer**
Discussion of fields of active inquiry and current interest in heat transfer. Considerations of major recent work and several summaries of associated contributions.

**3685 Nonlinear Wave Propagation**
Emphasis is on mathematical treatment of nonlinear effects associated with waves in continua. Some particular examples are taken from water waves, gasdynamics, elasticity, plasma physics, and electromagnetic theory. Topics include: Fourier analysis of linear waves; phase and group velocity; dispersion; energy propagation; caustics; kinematic waves; high-frequency expansions, diffraction, and ray theory. Nonlinear hyperbolic systems; characteristics; shock waves; energy dissipation; Burger's equation and its solution. Conservative dispersive systems. The Korteweg-deVries equation and the GGKM method of solution. Nonlinear WKB approximation. Variational principles and Hamiltonian equations for nonlinear dispersive waves. Conservation of wave

action. Nonlinear group velocity. Resonant wave interactions and instability of deep water waves.

# Medieval Studies

For further information about courses consult the Fields of The Classics, Comparative Literature, English, Germanic Studies, History, History of Art and Archaeology, Music, Philosophy, Romance Studies, Semitic Studies, and Slavic Studies.

## Arabic

**317 Islamic Texts in Arabic**

**318 Arabic Geographers and Historians**

**461 Medieval Arabic Belles Lettres ('Adab)**

**462 Arabic Philosophers**

## Classics

**367-368 Medieval Latin Literature**

**423 Vulgar Latin**

## Comparative Literature

**333-334 Medieval Literature**

**404 Medieval Arthurian Literature**

**639-640 Special Topics in Medieval Studies**

## English

**501 Readings in Old English**

**502 Beowulf**

**503 Middle English**

**504 Chaucer**

**506 Philological Problems in the Study of English Literature**

**508 The English Language**

**512 Medieval Drama**

**608 Studies in Medieval Literature**

## French

**401-402 History of the French Language**

**447-448 Medieval Literature**

**544 Medieval Seminar: The Old French Epic**

**555 Historical Phonology of French**

**558 Linguistic Structures of Old and Middle French**

## Germanic Studies

**401-402 History of the German Language**

**405-406 Introduction to Medieval Literature**

**502 Gothic**

**503-504 Old Saxon, Old High German, Old Low Franconian, Old Frisian**

**509-510 Old Norse**

**511 Sagas**

**521 Middle High German Literature I**

**522 Middle High German Literature II**

**671-672 Seminar in Germanic Linguistics**

## Hebrew

**305 Postbiblical Hebrew Prose II**

**307 Postbiblical Hebrew Poetry**

**432 Medieval Hebrew Literature**

## History

**303-304 Medieval History**

**335 Medieval Culture, 400–1150**

**336 Medieval Culture, 1150–1300**

**347 English Constitutional History I: To 1485**

**437 Church and State During the Middle Ages**

**635-636 Seminar in Medieval History**

**638 Seminar in Medieval History**

**639-640 Seminar in Latin Paleography**

## History of Art

**333 Early Medieval Art**

**334 Romanesque Art**

**335 Gothic Art**

**336 Medieval Italian Art**

**341 Flemish Art**

**342 Medieval and Renaissance German Art**

**531 Problems in Medieval Art and Architecture**

## Italian

**327-328 Dante**

**329 Early Italian Prose and Poetry**

**434 History of the Italian Language**

## Linguistics

**441-442 History of the Romance Languages**

**443-444 Comparative Romance Linguistics**

**449 Areal Topics in Romance Linguistics**

**561-562 Comparative Slavic Linguistics**

## Music

**516 Music and Poetry in France: Late Middle Ages and Renaissance**

**683-684 Seminar in Medieval Music**

## Philosophy

**303 Medieval Philosophy**

**580 Medieval Philosophy**

## Russian

**401-402 History of the Russian Language**

**501 Old Church Slavic**

**502 Old Russian**

**521 Russian Literature from the Beginnings to 1700**

## Semitic Literature in Translation

**409 Averroes and Averroism in Islam, Judaism, and Christianity**

## Spanish

**401 History of the Spanish Language**

**402 Old Spanish Texts**

**440 Medieval Literature**

## Society for the Humanities

**411 Seminar on Problems in Old Norse Historiography**

# Microbiology

**391A Natural Selection in the Bacteria**
A study of the comparative physiological and ecological relationships among bacteria and some related organisms. A number of groups of bacteria will be discussed in detail as well as factors which influence their ability to survive in nature. In addition, a number of lectures will be devoted to the theory and development of bacterial classification.

**391B Bacterial Ecology Laboratory**
Techniques for the isolation, cultivation, and detailed study of selected groups of organisms. Some of the more standard techniques of physiological study will be introduced.

**490A Microbial Physiology Lecture**
A study of the organization of physiological processes in microorganisms, including a study of structure, energy-yielding mechanisms, macromolecular biosynthesis, and growth and regulation.

**490B Microbial Physiology Laboratory**
Experiments on material covered in 490A will be used to introduce students to modern physiological research techniques, such as use of radioisotopes, large-scale growth of microorganisms, and the isolation and characterization of specific cellular components.

**492 Microbial Ecology**
An introduction to the basic principles of microbial ecology. Attention is given to the behavior, activity, and interrelationships of bacteria, fungi, algae, and protozoa in natural ecosystems.

**495A Microbial Genetics Lecture**
Genetics of bacteria and their viruses, with emphasis on the mechanisms of genetic phenomena.

**495B Microbial Genetics Laboratory**
Laboratory methods in the genetics of bacteria and their viruses.

**496 Selected Topics in Microbial Metabolism**
Selected topics pertaining to the energy metabolism, oxidative and fermentative abilities, and biosynthetic capacities of microorganisms. Where possible and appropriate, various microbial forms are compared.

**498 Virology**
A study of the basic physical, chemical, and biological properties of plant, animal, and bacterial viruses.

**590 Methods in Advanced Bacteriology**

**596 Molecular Immunology**
A study of the immune response with particular emphasis on the structure and evolution of immunoglobulins, the nature of antigen-antibody interactions and the molecular biology of antibody biosynthesis.

**691 Graduate Seminar in Microbiology**
Required of all graduate students majoring in microbiology.

**699 Microbiology Seminar**
Required of graduate students majoring in microbiology and open to all who are interested.

See also Agronomy 506; and Veterinary Medicine 941, 942, 943-944, 945.

# Music

**516 Music and Poetry in France: Late Middle Ages and Renaissance**
Changing interrelations between vernacular poetry and secular music from the late fourteenth century to the time of Ronsard.

**551 Introduction to Twentieth-Century Music**
A detailed course in analysis of representative works by important composers in the first half of the twentieth century, including Bartók, Hindemith, Schoenberg, Stravinsky, Webern, and some American composers.

**552 The Piano Music of Claude Debussy**
The presentation, analysis, discussion, and comparison of the solo piano works with emphasis on musical (rather than technical) problems of performance, including style, sound, and color.

**553 Analysis of Structure and Function in Tonal Music**
In introduction to the systematic analysis of thematic and formal structure from the phrase, subphrase, and motive to the movement as a whole. The concept of harmonic function is expanded to include key function, and the two levels are interrelated through a graphic representation of their profiles. Emphasis will be on the Viennese classics, but considerable attention will be given to the process of tonal expansion in the nineteenth century.

**557-558 Composition**
Intended to acquaint the student with compositional practices in contemporary styles and to develop his creative abilities.

**581-582 Introduction to Bibliography and Research**
The basic materials and techniques of musicological research.

**583 Early Theories of Tonality**
The formulations of representative theorists of modality, figured bass, and root progression will be examined for the light they shed on the emergence of tonality. The validity of theoretical statements will be tested through analysis of contemporaneous music.

**584 Seminar in Renaissance Music**
An important musical manuscript will be transcribed and its musical, literary, and social background investigated.

**585 Schoenberg, Bartók, and Stravinsky**
Comparative stylistic study, through performance and analysis, of representative works of the three composers.

**587 Mozart**
Research in the music of Mozart and his contemporaries.

**654 Seminar in Analytic Techniques for Twentieth-Century Music**
Detailed analysis of a limited number of larger works representative of main trends in twentieth-century music. Different works are chosen each year.

**656 Problems in Music Theory**
Preparation of twentieth-century music research projects for the M.F.A. and D.M.A. degrees.

**683-684 Seminar in Medieval Music**
Selected topics from the Middle Ages with special attention to the development of measured notation and to the problems of preparing scholarly editions of early music.

**687-688 Debussy to Boulez**
Historical studies in twentieth-century music. Each student will study many works of a single composer, in relation to that composer's life and thought and especially his knowledge of other music. Composers will be chosen in accordance with the student's abilities and interests.

**689-690 Liturgical Chant in the West**
A study of selected aspects of the liturgical chant of Western Christian rites during the Middle Ages.

**Solo Literature for Viola da Gamba (Society for the Humanities Seminar 505)**

**The Division and Lyra Viols (Society for the Humanities Seminar 506)**

# Neurobiology and Behavior

**320 Neurobiology and Behavior**
Evolution of behavior, cueing of behavior, social and nonsocial behavior, neuroanatomy, neurophysiology, neurochemistry, neural networks, memory.

**323 Physiological Psychology (Psychology 323)**
Selective examination of neural, endocrine, and biochemical functions related to emotion, memory, learning, and sleep.

**323A Physiological Psychology Laboratory (Psychology 323A)**
Experiments on physiological aspects of conditioning and memory in vertebrates and invertebrates, interactions between hormones and behavior, and effects of brain lesions on behavior. A final original experiment will be planned and carried out.

**325 Fine Structure of the Nervous System**
A course on the cellular organization of the nervous system. Special emphasis on development, functional relationships, and ultrastructure.

**421 Comparative Vertebrate Ethology**
A survey of the methods and principles of vertebrate ethology for students specializing in this field or for those in other branches of zoology wishing to broaden their knowledge of animal behavior. Emphasis is placed on the causation, function, biological significance, and evolution of species-typical behavior. The laboratories are designed to give firsthand knowledge of the material covered in lectures.

**423 Animal Communication**
The course will emphasize the functional aspects of biological signals, their physical properties, and the physiological mechanisms underlying their generation and reception. Lectures will examine in detail selected biological communication problems from each of the known sensory modalities. Discussion will cover signal analysis, transmission properties, and the limitation of each type of communication. Laboratories will include behavioral observations under both field and captive conditions and individual experience with signal recording and analysis.

**427 Sensory Function (Psychology 427)**
Sensory receptors and the central nervous system transformation of afferent activity will be considered in relation to human and nonhuman behavior, and to the adaptive significance of behavior. The receptor will be examined in terms of anatomy, biochemistry, biophysics of transduction, and the central nervous system control of peripheral input.

**427A Sensory Function, Laboratory**
Experiments on the principles of receptor function and afferent neural activity.

**428 Neurochemistry**
Special features of the composition and metabolism of neural tissue will be discussed. The identification of synaptic transmitters in the nervous system, including their specific localization, biosynthesis and metabolism, release inactivation, and action on post-synaptic receptors will be considered in detail. Chemical aspects of vision and of neuronal development and maturation will also be studied.

**429 Research in Neurobiology and Behavior**
Practice in planning, conducting, and reporting independent laboratory and/or library research programs.

**523 Ecological Aspects of Animal Behavior**
A discussion of the interrelationships of animal behavior and ecology, with emphasis upon: behavior adaptations to the environment; ecological significance of diverse social systems; advantages of territoriality; coloniality and cooperative breeding; monogamy, polygamy, and promiscuity; role of social behavior in population regulation; evolution of altruistic behavior.

**524 Behavioral Neurophysiology**
Small group discussions of original research papers, supplemented with lectures and demonstrations. The general subject is the relationship between animal behavior and physiological properties of individual nerve cells. Areas included are sensory and central neuronal control of behavior, sensory and synaptic electrophysiology, principles of integration. Specific topics vary somewhat, partly on the basis of student interests.

**524A Behavioral Neurophysiology, Laboratory**
Intensive training in the analysis of simple behavior, and in neurophysiology (extracellular single unit recordings stressed). Most students will work on original research projects.

**525 Functional Organization of the Mammalian Nervous System**
Function of the nervous system considered primarily from an electrophysiologic viewpoint. Where appropriate, important studies of reflexology, chemical and feedback control, and comparative anatomy will be utilized. Laboratory studies will include electrical activity of cells, reflexes, decerebrate rigidity, acoustic microphonic response, subcortical stimulation, and evoked and spontaneous cortical activity.

**526 Bioelectric Systems**
Deals with the application of systems techniques to biological problems. Electrical activity of nerve cells; generation and propagation of nerve impulse; voltage clamp technique, Hodgkin-Huxley models; electrical excitability and transfer function of neuromuscular systems; synaptic transmission; models of nerve cells and oscillatory activity. Nerve nets: *(a)* evoked activity; *(b)* spontaneous activity; *(c)* simulation and computer analysis. Functional neuroanatomy of the brain; transfer characteristics of sensory receptors; sensory encoding and processing in the peripheral and central nervous systems; neural mechanisms for vision and hearing.

**622 Seminar in Ecological Animal Behavior**
This course, designed to provide individual experience in the design, execution, and reporting of a field research project, is structured around a required ten-day field trip (usually to Florida) during the spring vacation. The student's travel and housing will be provided. In-

terested students should contact Mr. Harrison Ambrose during the fall term.

**629 Advanced Topics in Neurobiology and Behavior**
A seminar course designed to provide several study groups each semester on specialized topics. A group may meet for whatever period is judged adequate to permit coverage of the selected topics. Ordinarily, topics will be selected and circulated during the preceding semester. Suggestions for topics should be submitted to the chairman of the Section of Neurobiology and Behavior.

See also Psychology 323, 326, 465.

## Nuclear Science and Engineering

**8301 Nuclear Energy and Environment**
Fundamentals of nuclear radiations and their measurement and interaction with matter, the natural radiation environment, and sources of man-made radioactivity (five weeks); radiation chemistry, radiation biology, somatic and genetic effects of nuclear radiation, movements of radioactive materials in the biosphere, and bases of radiation protection standards (five weeks); environmental effects of nuclear electricity generation and nuclear fuel mining, processing, and waste storage, control of radiation hazards, and waste heat problems (four weeks).

**8303 Introduction to Nuclear Science and Engineering**
An introductory course designed to acquaint students with low-energy nuclear physics and some of its practical applications. Topics will include: properties and structure of nuclei; radiations emitted by nuclei and their interaction with matter; nuclear reactions, with emphasis on fission and fusion processes; the neutron chain reaction; types and uses of nuclear reactors; practical applications of nuclear radiations, e.g., neutron activation analysis and radioactive tracer analysis.

**8309 Low-Energy Nuclear Physics**
The nuclear interaction. Properties of ground and excited states of nuclei and models of nuclear structure; alpha, beta, gamma radioactivity and fission; low-energy nuclear reactions—resonant and nonresonant scattering and absorption. At the level of *Introduction to Nuclear Physics* by Enge.

**8310 Nuclear Structure Physics**
Topics include: symmetry properties of nuclei, the collective model, basic reaction theory, compound and direct reactions, the optical model, charged particle reactions. At the level of *Physics of the Nucleus* by Preston.

**8312 Nuclear Reactor Theory I**
The physical processes in the neutron chain reaction are described. The theory of neutron slowing down, moderation, and spatial diffusion are developed and applied to these processes. The theories of fast effect, resonance absorption, and thermal utilization are developed for homogeneous reactors. Nuclear reactor kinetics and neutron transport theory are introduced. At the level of *Nuclear Reactor Theory* by Lamarsh.

**8313 Nuclear Reactor Theory II**
A continuation of 8312, primarily intended for students planning research in nuclear reactor physics and engineering. The Boltzmann linear transport equation, its adjoint, and their approximate solutions are developed and applied to the heterogeneous neutron chain reactor. The theories of fast fission effect, resonance escape, and thermal utilization are developed for heterogeneous reactors. The escape probability formulation of reactor lattices, the neutron importance function, perturbation theory, temperature coefficients of reactivity, and fission product poisoning are also treated. At the level of *The Physical Theory of Neutron Chain Reactors* by Weinberg and Wigner.

**8333 Nuclear Reactor Engineering**
A selected set of topics representing the fundamentals of nuclear reactor engineering; energy conversion and power plant thermodynamics, reactor plant fluid flow and heat transfer, thermal stresses, radiation protection and shielding, routine and accidental discharge of radionuclides from nuclear reactors, and nuclear fuel cycles. At the level of *Nuclear Reactor Engineering* by Glasstone and Sesonske.

**8334 Nuclear Engineering Design Seminar**
A group design study of a selected nuclear reactor system. Emphasis is on safety, siting, and radiation protection in the design of nuclear power systems.

**8351 Nuclear Measurements Laboratory**
Laboratory experiments plus lectures on interaction of radiation with matter and on radiation detection, including electronic circuits. Twenty different experiments are available in the fields of nuclear and reactor physics and radiation protection, including experiments on emission and absorption of radiation, radiation detectors and nuclear electronic circuits, interactions of neutrons with matter (absorption, scattering, moderation, and diffusion), activation analysis and radiochemistry, and properties of a subcritical assembly. Many experiments use the TRIGA Reactor. The student is expected to select and perform eight to ten experiments. Some stress is placed on independent work by the student.

**8352 Advanced Nuclear and Reactor Laboratory**
Laboratory experiments plus lectures on experimental methods in nuclear physics and reactor physics. Ten different experiments are available, among them ones using the Zero Power Reactor critical facility.

## Nutrition

**Animal Science 410 Principles of Animal Nutrition**
The principles of nutrition, involving a discussion of proteins, fats, carbohydrates, vitamins, and minerals and their importance in animal nutrition.

**Animal Science 411 Principles of Animal Nutrition, Laboratory**
Laboratory problems with animals will be designed to introduce the student to techniques of experimentation in nutrition.

**Animal Science 505 Biochemistry of Forages and Their Utilization**
The nutritional biochemistry of forage plants, rumen fermentation and the factors influencing the use of cellulosic materials as food. Chemical composition of plants and factors influencing their nutritive value.

**Animal Science 511 Laboratory Work in Animal Nutrition**
Classical and contemporary techniques of nutritional experimentation with several animal species such as rats, guinea pigs, chicks, pigs, and sheep are employed to illustrate nutritional principles. Each student engages in a series of short research projects and a larger experiment which he is responsible for planning, executing, and reporting. Application of biochemical methods to the solution of nutritional problems is emphasized.

**Animal Science 513 Forage Analysis**
Nutritive evaluation of forages and related materials

through various chemical and in vitro procedures. Course will include a term paper summarizing results of independent laboratory study of either materials or methods. The student may develop or provide his own forage materials.

**Animal Science 619, Poultry Science 619, Graduate School of Nutrition 619 Field of Nutrition Seminar**

**Graduate School of Nutrition 580 International Nutrition Problems, Policy, and Programs**
A review of food and nutrition problems, policy, and programs especially as they relate to developing countries. Emphasis is placed on the need to coordinate the efforts of various government ministries or departments including those of agriculture, education, economics, health, and community development. Among topics discussed are planning and evaluation of applied nutrition programs; education and training in nutrition; the importance of social and cultural factors; methods of increasing the use of protein-rich foods; assessment of nutritional status; the role of FAO, WHO, UNICEF and other agencies; action in case of famine; the integration of nutrition with other projects of disease control in developing countries.

**Graduate School of Nutrition 620 General Nutrition**
This course is offered to students whose principal academic training has been in a field other than nutrition. It is designed to meet their need for a basic but intensive introduction to the principles, history, and applications of nutrition.

**Graduate School of Nutrition 650 Clinical and Public Health Nutrition**
Designed to familiarize the student with some of the applications of nutrition to clinical and public health problems.

**Graduate School of Nutrition 660 Special Topics in Nutrition**
Designed for a student who wishes to become well informed in any specific topic he selects which is related directly or indirectly to nutrition. The course may include individual tutorial study, experience in research laboratories, a lecture series on a special topic selected by a professor or a group of students, and/or selected lectures of a course already offered. Topics can be changed so that the course may be repeated for credit.

**Graduate School of Nutrition 700 Nutrition Seminar**
Intended primarily for Graduate School of Nutrition students; it is recommended that they attend throughout the year.

**Poultry Science 415 Poultry Nutrition**
Discussion of applications of principles of nutrition to feeding poultry. Feed formulations will be stressed, with emphasis on linear programming and computer formulation.

**Poultry Science 511 Special Topics in Nutrition**
Various topics dealing with avian nutrition, to be announced before the beginning of the term, will be discussed. Students may also register for a special project to obtain experience in research with avian species.

**Veterinary Pathology 931 Pathology of Nutritional Diseases**

**Advanced Nutrition Series**
A series of nutrition courses offered jointly by the Department of Human Nutrition and Food, College of Human Ecology; Department of Animal Science and Department of Poultry Science, College of Agriculture and Life Sciences; and the Graduate School of Nutrition. The subjects covered include the biochemical and physiological bases of digestion, absorption, transport, and metabolism of nutrients; species differences where applicable; historical as well as current concepts of nutrition.

**Human Nutrition and Food 501 Proteins and Amino Acids**

**Poultry Science 502 Lipids and Carbohydrates**

**Animal Science 503 Nutritional Energetics**

**Poultry Science 504 Minerals and Vitamins**

See also the Field of Human Nutrition and Food, HNF 441, 445, 512, 514, 515, 524, 605.

# Operations Research

**9114 Consumer Products Engineering (Chemical Engineering 5790)**

**9361 Probabilistic Models in Industrial Engineering and Operations Research**
Basic probabilistic techniques will be developed and applied in engineering problem areas. Topics to be covered include: transform methods (particularly the z-transform and the Laplace transform); the Poisson process with extensions; the general birth-death process; a variety of queuing and inventory models. Theoretical background and derivations will be included to make clear the assumptions and limitations of the models and to introduce the student to the problems of formulation of analogous models found in engineering and operational situations.

**9383 Applications of Computer Science in Industrial Engineering and Operations Research**
The application of computers in the analysis of industrial engineering and operations research problems. Simulation methodology. Design of data processing systems for operational control. Use of statistical and mathematical programming packages.

**9460 Introduction to Probability Theory with Engineering Applications**
Definition of probability and basic rules of probability theory. Random variables, probability distributions, and expected values. Special distributions important in engineering work and relations among them; elementary limit theorems. Introduction to stochastic processes and Markov chains and their applications in the construction of mathematical models of operation, with emphasis on queuing and inventory models.

**9470 Introduction to Statistical Theory with Engineering Applications**
The application of statistical theory to problems associated with the analysis of data and inference drawn therefrom. Principles of statistical inference: estimating the value of the unknown parameters of probability distributions, testing hypotheses concerning these parameters; elements of statistical decision theory. Introduction to correlation theory and curve fitting by least squares. Applications in regression, statistical control, and experimentation.

**9481 Introduction to Computer Systems and Organization (Computer Science 401)**

**9501 Engineering Administration**
Organization of the engineering function, planning and analysis of engineering activities. Project management and control. Problems of innovation and introducing technological change. Measurement and evaluation of engineering activities. Selected topics from current literature.

**9511 Industrial Systems Design**
A discussion of the problems of design and control of industrial systems. The development of design alternatives and their evaluation. Measures of system effectiveness and sensitivity. The role and place of information handling in systems control. Experimental procedures in testing system design with computer simulation. Term papers and design projects by individuals and groups will be expected.

**9512 Statistical Methods in Quality and Reliability Control**
Control concepts: control chart methods for attributes and variables; process capability analysis; attributes acceptance sampling plans and procedures; double and multiple sampling plans; elementary procedures for variables; acceptance-rectification procedures; basic reliability concepts; exponential and normal distributions as models for reliability applications; life and reliability analysis of components; analysis of series and parallel systems; stand-by and redundancy; elementary sampling-inspection procedures used for life and reliability.

**9513 Systems Engineering**
Methods of describing, analyzing, and manipulating complex, interrelated open systems. Graphical and mathematical analysis. Techniques of design of transportation, service, and information systems and appropriate evaluation methods.

**9521 Production Planning and Control**
Methods for the planning and control of large-scale operations with emphasis on manufacturing systems. Among the areas covered will be sales and production forecasting; manufacturing planning; routing, scheduling, and loading; sequencing; dispatching; planning and control of inventories. Emphasis will be on mathematical, statistical, and computer methods for performing these functions. The empirical systems and procedures in use will also be discussed and evaluated.

**9522 Operations Research I**
Model design, methodology of operations research, linear programming, transportation problem, assignment problem, dual theorem, parametric linear programming, integer programming, nonlinear programming, dynamic programming, introduction to inventory theory; game theory, comprehensive problems, and case studies.

**9523 Operations Research II**
Models for inventory and production control. Replacement theory; queuing, including standard birth and death process model and nonstandard models; application of queuing theory. Simulation. Illustrative examples and problems.

**9524 Problems in Operations Research**
An advanced seminar concentrating on problem definition, measures of effectiveness, applicability of various analytical methods to the solution of real problems.

**9525 Scheduling Theory**
Scheduling problems; problem definition and performance measures. Single resource scheduling. MxN scheduling problems. Priority queuing approaches. Simulation of job-shop dispatching and heuristic procedures.

**9526 Mathematical Models—Development and Application**
Examination of probabilistic and deterministic models in relation to industrial engineering work. The function of models and their usefulness in analysis, synthesis, and design. Emphasis will be given to the application of various models, their modification to fit special circumstances, and the development of new models to describe particular conditions or situations. Markov chains and dynamic programming will be discussed.

**9527 Theory of Traffic Flow**
Study of various mathematical theories of traffic flow. Microscopic models (car following models). Macroscopic models (kinematic wave theory). Stochastic properties of traffic flow at low density. Probability models for traffic lights and optimal control of signalized intersections. Traffic flow on transportation networks. Application to traffic assignment. Traffic networks simulation system.

**9529 Problems and Techniques in Optimization**
Selected topics in the application of operations research techniques to problems encountered in actual situations. Specific topics to be treated, generally related to mathematical programming, are at the discretion of the instructor. Typical of subjects discussed are column generation methods, network algorithms, techniques for handling uncertainty, computation of nonlinear programs, and enumeration methods for integer problems as applied to scheduling, location, distribution, and engineering design problems.

**9530 Mathematical Programming**
The dual theorem of linear programming. Geometric and algebraic characterizations of the problem. Adjacent extreme point methods including degeneracy. Data organization for computation. Postoptimality analysis. Transportation and other network programming problems. Primal-dual and decomposition methods. Introduction to two-person games and to integer, nonlinear, and stochastic programming.

**9531 Integer Programming**
Discrete optimization. Emphasis is on the linear programming problem in which the variables are restricted to be integers. Theory, computation, and applications will be discussed.

**9532 Nonlinear Programming**
Necessary and sufficient conditions for unconstrained and constrained optima. Computational methods, including interior (e.g., penalty functions), boundary (e.g., gradient projection), and exterior (e.g., cutting plane) approaches.

**9533 Combinatorial Analysis**
Incidence systems such as block designs, finite geometries, and other combinational designs, counting and enumeration techniques, combinatorial extremum problems, matroids, coding theory, selected topics in graph theory.

**9534 Graph Theory**
Finite, infinite, directed, undirected, combinatorial, and topological graphs. Connectedness, planary and inbedding problems, enumeration problems, coloring and matching problems, automorphism group of a graph, generalizations of graphs, matrix methods, network problems. Applications to electrical networks, economics, and sociometry.

**9535-9536 Game Theory I–II**
Two-person-zero-sum games; the minimax theorem, relationship to linear programming. Two-person-general-sum games. Noncooperative $n$-person games; Nash equilibrium points. Cooperative $n$-person games; the core, stable sets, Shapley value, bargaining set, kernel, nucleolus. Games without side payments. Games with infinite numbers of players. Economic market games. Mathematical techniques of game theory.

**9537 Dynamic Programming**
A study of the optimization of sequential or multistage decision processes based upon the application of the dynamic programming principle of optimality. Theory, computation, and applications will be discussed.

**9538 Game Theory Seminar**
A seminar in which students read and report on current papers of interest in game theory, primarily in the area of *n*-person cooperative theory.

**9539 Selected Topics in Mathematical Programming**
Current research topics such as integer programming over finitely generated groups, chance-constrained games, duality theory, infinite games.

**9540-9541 Network Flows and Extremal Combinatorial Programs I–II**
The theory of flows in capacity-constrained networks and related areas in applied combinatorial mathematics. Topics include: maximum flow, feasibility criteria, minimum path, minimum cost flow, maximum dynamic flow, out-of-kilter algorithm, multiterminal flows, network synthesis, project cost curves, scheduling problems, set representatives, (0,1)-matrices, matching, packing and covering problems, matroid partition and intersection, flows in infinite graphs, blocking systems, frames, blocking and antiblocking pairs of polyhedra.

**9550 Engineering Economic Analysis**
Use of cost information for financial reporting, cost control, and decision making. Specific topics include theory of double-entry accrual accounting; use of costs in manufacturing; job order *vs.* process costing; predetermined overhead rates; standard costs and variances. Modification of cost information for decision making: cost dichotomies; profit-volume charts; direct costing; costing of joint products and by-products; economic lot sizes; use of costs in other models of operation research. Capital investment planning; the time value of money; use of interest rates; ranking procedures for proposed projects; handling of risk and uncertainty.

**9551 Advanced Engineering Economic Analysis**
Topics include capital investment planning procedures, project ranking, interdependence of productive investment, and financing decisions. The cost of capital controversy. Handling of risk and uncertainty. Applications of linear programming to capital budgeting problems. Theory of the firm, including objectives, market structure, and pricing policies. Measures of performance. Problems of profit measurement in the decentralized firm, including discussion of transfer pricing.

**9560 Applied Stochastic Processes**
An introduction to stochastic processes with emphasis on a variety of applications of the basic theory. The following topics are covered: second order processes; Markov chains and processes; diffusion processes, renewal theory and recurrent events; fluctuation theory; random walks, branching processes; Brownian motion; birth and death processes. Examples are drawn from queuing theory, population growth and other ecological models, inventory theory, etc.

**9561 Queuing Theory**
Definition of a queuing process. Poisson and Erlang queues. Imbedded chains. Transient behavior of the systems M/G/1 and GI/M/1. The general queue GI/G/1. Bulk queues. Applications to specific engineering problems such as shop scheduling, equipment maintenance, and inventory control.

**9562 Inventory Theory**
An introduction to the mathematical theory of inventory and production control, with emphasis on the construction and solution of mathematical models. Topics will be drawn from the recent technical literature and will include deterministic and stochastic demands; dynamic programming and stationary analysis of inventory problems; renewal theory applied to inventory problems; multiechelon problems; statistical problems; and production smoothing.

**9565 Time-Series Analysis**
The Hilbert space projection theorem and its application to linear prediction and linear statistical inference. Spectral representations of wide sense stationary processes. Estimation of spectral densities and other topics in empirical spectral analysis. Discussion of several time-series models and the basic statistical techniques associated with the models.

**9569 Selected Topics in Applied Probability**
Selected topics in applied probability for advanced students. Topics will be chosen from current literature and research areas of the staff.

**9570 Intermediate Statistics**
Distributions used in the analysis of the properties of standard statistical tests, including noncentral F distributions. Power of standard statistical tests. Distributions of estimators. Rational choice of sample size. Simple, multiple, and partial correlation. Regression analysis. Tests of goodness of fit.

**9571 Design of Experiments**
Use and analysis of experimental designs such as randomized blocks and Latin squares; analysis of variance and covariance; factorial experiments; statistical problems associated with finding best operating conditions, response-surface analysis.

**9572 Statistical Decision Theory**
The general problem of statistical decision theory and its applications. The comparison of decision rules; Bayes, admissible, and minimax decision rules. Problems involving a sequence of decisions over time, including sequential analysis. Use of the sample cumulative distribution function and other nonparametric methods. Applications to problems in the areas of inventory control, sampling inspection, capital investment, and procurement.

**9573 Statistical Multiple-Decision Procedures**
The study of multiple-decision problems in which a choice must be made among two or more courses of action. Statistical formulations of the problems. Fixed-sample size, two-stage, and sequential procedures. Special emphasis on applications to ranking problems involving choosing the "best" category where goodness is measured in terms of a particular parameter of interest. Recent developments.

**9574 Nonparametric Statistical Analysis**
Estimation of quantities, c.d.f.s. and p.d.f.s. Properties of order statistics and rank-order statistics. Hypothesis testing in one- and two-sample situations. Large-sample properties of tests and asymptotic distributions of various test statistics.

**9579 Selected Topics in Statistics**
Selected topics chosen from such fields as nonparametric statistical methods, sequential analysis, multivariate analysis.

**9580 Digital Systems Simulation**
The use of a program for a digital computer to simulate the operating characteristics of a complex system in time. Discussion of problems encountered in construction of a simulation program; synchronization and file maintenance, random-number generation, random-deviate sampling. Programming in simulation languages. Problems in the design of effective investigations using simulation; statistical considerations when sampling from a simulated process.

**9582 Data Processing Systems**
The design of integrated data-processing systems for

operational and financial control; questions of system organization, languages, and equipment appropriate to this type of application; file structures, addressing, and search problems, sorting techniques; problems of multiple-remote-input, on-line data-processing systems; techniques of system requirement analysis.

**9589 Selected Topics in Information Processing**
Selected topics in the design of computer systems to implement operations research techniques.

**9590 Special Investigations in Industrial Engineering and Operations Research**

**9591 Operations Research Graduate Seminar**
A weekly 1½ hour seminar devoted to presentation, discussion and study of research in the Field of Operations Research. Distinguished visitors from other universities and institutions, both domestic and foreign, as well as faculty members and advanced graduate students of the Department and the University speak on topics of current interest.

**9593-9594 Industrial Engineering Graduate Seminar**
A weekly meeting to discuss assigned topics and hear presentations of the state of the art from practitioners in the field.

**9598-9599 Project**
Must be completed by each candidate for the professional master's degree during the last two terms of matriculation.

# Philosophy

**301-302 Modern Philosophy I and II**

**303 Medieval Philosophy**

**305 Special Topics in the History of Philosophy**

**307 Kant**

**309 Philosophy of Marx**

**311 Existentialism and Phenomenology**

**314 Introduction to Philosophy of Mathematics**

**321 Aesthetics**

**325 Ethical Theory**

**327 Introduction to Philosophy of Science**

**333 Philosophy of Psychology**

**403 Plato and Aristotle**

**412-413 Deductive Logic**

**414 Philosophy of Logic**

**415 Problems in Philosophy of Language**

**417 Theory of Knowledge**

**418 Inductive Logic**

**419 Intensional Logic**

**425 Contemporary Ethical Theory**

**427 Problems in Philosophy of Science**

**433 Problems in Ethics and Philosophy of Mind**

**551 Philosophy of Religion**

**576 Ancient Philosophy**

**580 Medieval Philosophy**

**585 Ethics and Value Theory**

**587 Aesthetics**

**588-589 Metaphysics**

**590 Philosophy of Language**

**591 Philosophy of Mind**

**594 Theory of Knowledge**

**595 Semantics and Logic**

**596 Logic**

**597 The Philosophy of Science**

**600 Informal Study**
To be taken by graduate students only in exceptional circumstances and by arrangement made by the student with his Special Committee and the faculty member who has agreed to direct the study.

See also Classics (Courses on the Presocratics, Plato, Aristotle, Lucretius, and Cicero); History (Courses on the history of science); Linguistics 513-514; Mathematics (Courses on logic and theory of models); Semitic Studies (Courses on both Arabic and Jewish philosophers).

# Physics

**431-432 Introductory Theoretical Physics I and II**
Fall term. Mechanics. Includes Newtonian mechanics, Lagrange's and Hamilton's equations, central forces, rigid body motion and small oscillations. At the level of *Mechanics,* second edition, by Simon. Spring term. Electricity and magnetism. Includes electrostatics, magnetostatics, boundary value problems, dielectric and magnetic media, circuit theory, Maxwell's equations and propagation of electromagnetic waves. At the level of *The Physics of Electricity and Magnetism* by Scott.

**500 Informal Graduate Laboratory**

**505-506 Design of Electronic Circuitry**
Circuit techniques and design in electronic measurement and instrumentation with emphasis on pulse wave forms. At the level of *Pulse Electronics,* 1965, by Littauer.

**510 Advanced Experimental Physics**
About seventy different experiments are available among the subjects of mechanics, acoustics, optics, spectroscopy, electrical circuits, electronics and ionics, heat, x rays, crystal structure, solid state cosmic rays, and nuclear physics. The student is expected to perform four to eight experiments selected to meet his individual needs. Stress is laid on independent work. Also taught in Summer School.

**520 Projects in Experimental Physics**
Projects of modern topical interest that involve some independent development work by the student. Opportunity for more initiative in experimental work than is possible in 510. One or two projects in different areas typically comprise a term's work (e.g., with the Cornell synchrotron, or with a liquid helium cryostat, or with both).

**551 Formalism of Classical Mechanics**
Lagrangian and Hamiltonian formulation of classical mechanics. At the level of *Mechanics,* by Landau and Lifshitz.

**561 Classical Electrodynamics**
Maxwell's equations, electromagnetic potentials, electrodynamics of continuous media (selected topics), special relativity, and radiation theory. At the level of *Classical Electrodynamics* by Jackson.

**562 Thermal, Statistical, and Continuum Physics**
Hydrodynamics, thermodynamics, and introductory statistical mechanics, including ensemble theory, Fermi-

Dirac and Bose-Einstein statistics with applications. At the level of *Statistical Physics, Fluid Mechanics,* by Landau and Lifshitz.

**572 Quantum Mechanics I**
Dirac's formulation of quantum mechanics, transformation theory. Symmetries: angular momentum, the exclusion principle, time reversal. Elements of scattering theory and of perturbation theory. At the level of *Quantum Mechanics* by Gottfried. A familiarity with elementary aspects of the Schroedinger equation, including its application to simple systems such as the hydrogen atom, is assumed.

**574 Quantum Mechanics II**
Discussion of various applications of quantum mechanics such as collision theory, theory of spectra of atoms and molecules, theory of solids, emission of radiation, and relativistic-quantum mechanics. At the level of *Quantum Mechanics of One- and Two-Electron Atoms* by Bethe and Salpeter. Required of all Ph.D. majors in Theoretical Physics.

**612 Experimental Atomic and Solid State Physics**
Lectures on techniques and design principles, with emphasis on the study of solids by their interactions with electromagnetic fields. Topics include sources and detectors, scanning and resonance techniques, signal-processing, sample characterization, and environmental control.

**614 Experimental High-Energy Physics**
Design principles of high-energy apparatus: accelerators, beam transport, detection systems, etc., with examples of their applications. Practice in the use of relativistic kinematics. Statistical analysis in the design and interpretation of experiments.

**635 Solid State Physics I**
An introduction to solid state physics including studies of lattice vibrations, the electronic structure of metals and insulators, with applications to electrical, thermal, and transport properties. At the level of *Principles of Theory of Solids,* 1964, by J. M. Ziman. Expected of every Ph.D. majoring or minoring in Experimental Physics.

**636 Solid State Physics II**
The concepts developed in 635 are extended and applied to a survey of the following: band theory and the Fermi surface in metals, localized states, magnetism, neutron and light scattering, and phenomenological superconductivity.

**645 Nuclear and Particle Physics**
An introduction to the study of nuclear and particle physics, emphasizing the interaction between theory and experiment in developing the basic ideas. Topics to be covered include: general properties of nuclear matter, the two-nucleon system, beta decay, role of the pion in nuclear forces, classification of elementary particles, weak interactions of elementary particles. At the level of *Nuclear Interactions,* 1964, by DeBenedetti.

**646 High-Energy Particle Physics**
The physics of nucleons, mesons, and strange particles from an experimental point of view. High-energy phenomena, as opposed to classical nuclear physics, will be stressed. At the level of *An Introduction to Elementary Particles* by Williams.

**651 Advanced Quantum Mechanics**
Relativistic quantum mechanics with emphasis on perturbation techniques. Extensive applications to quantum electrodynamics. Introduction to renormalization theory. At the level of *Relativistic Quantum Mechanics* by Bjorken and Drell.

**652 Quantum Field Theory**
Canonical field theory, model field theories, Green's functions, renormalization. Introduction to analytic properties of scattering amplitudes and dispersion relations. Applications to strong interactions. At the level of *Relativistic Quantum Fields* by Bjorken and Drell.

**653 Statistical Physics**
A survey of topics in contemporary statistical physics, such as the Boltzmann equation, plasmas, sound propagation, phenomenological Fermi liquid theory, critical phenomena of simple fluids and ferromagnets, classical fluids, introduction to Kubo formulae and Greene's functions, and superfluids. At the level of *Statistical Physics* by Landau and Lifshitz.

**654 Theory of Many-Particle Systems**
The equilibrium and transport properties of microscopic systems of many particles are studied at zero and finite temperatures. Thermodynamic Green's function techniques are introduced and applied to such topics as normal and superconducting Fermi systems, superfluidity, magnetism, and insulating crystals.

**657 Theory of Nuclei**

**661 High-Energy Phenomena**
Topics of current interest in the theory of strong interactions. At the level of *Dispersion Relations* by Klein.

**665 Topics in Theoretical Astrophysics**
Typical topics are: theory of stellar structure, theory of stellar atmospheres, and theories of interstellar medium. Topics and their treatment will vary from year to year.

**680 Special Topics**
Typical topics are: group theory, analyticity in particle physics, weak interactions, superfluids, stellar evolution, plasma physics, cosmic rays, general relativity, low-temperature physics, x-ray spectroscopy or diffraction, and magnetic resonance.

**690 Independent Study in Physics**
Special graduate study in some branch of physics, either theoretical or experimental, under the direction of any professional member of the staff.

**Applied Physics 8262 Physics of Solid Surfaces**

**Astronomy and Space Science 431 Introduction to Astrophysics I**

**Astronomy and Space Science 432 Introduction to Astrophysics II**

**Astronomy and Space Science 509 Theory of Gravitation**

**Astronomy and Space Science 510 Cosmology and Relativistic Astrophysics**

**Astronomy and Space Science 530 Nuclear Astrophysics**

**Chemistry 596 Statistical Mechanics**

**Chemistry 505-506 Advanced Inorganic Chemistry**

**Computer Science 311 Introduction to Computer Programming**

**Computer Science 401 Computer Organization and Programming**

**Computer Science 404 Advanced Computer Programming**

**Electrical Engineering 4531 Quantum Electronics I**

**Electrical Engineering 4661 Kinetic Equations**

**Materials Science and Engineering 6603 Crystal Mechanics**

**Materials Science and Engineering 6611 Principles of Diffraction**

**Nuclear Science and Engineering 8309 Low Energy Nuclear Physics**

**Theoretical and Applied Mechanics 1772 Space Flight Mechanics**

**Theoretical and Applied Mechanics 1773 Mechanics of the Solar System**

**Biochemistry 431, 433 Principles of Biochemistry**

**Biochemistry 531, 533 Intermediate Biochemistry**

## Physiology

**Biological Sciences 414 Mammalian Physiology**
A general course in mammalian physiology including circulation, respiration, digestion, metabolism, renal function, endocrinology, and the nervous system.

**Biological Sciences 427 Sensory Function**
Sensory receptors and the central nervous system transformation of afferent activity will be considered in relation to human and animal psychophysical data and to the adaptive significance of behavior. The receptors will be examined in terms of anatomy, biochemistry, biophysics of transduction, and the central nervous system control of peripheral input. Information and signal detection theories will be applied.

See also Animal Science 427, 451; Veterinary Medicine 915, 916, 917, 918, 921, 922, 923, 924, 928; Botany, 547; and Neurobiology and Behavior, 522.

# Plant Breeding and Biometry

## Plant Breeding

**450 Special Problems in Research**

**503 Methods of Plant Breeding I**
Principles and practices of plant breeding. Each of the possible variety forms is described, and the methods of producing them are discussed.

**505 Physiological Genetics of Crop Plants**
Genetic, biochemical, and molecular mechanisms controlling plant variation in physiological phenomena such as photosynthesis, respiration, translocation, self-incompatibility, male sterility, seed dormancy, and heterosis will be discussed. Biochemical and molecular mechanisms through which environmental factors like temperature, light, mineral elements, and water interact with genetics to alter phenotypic expressions of plant growth and development will also be covered. These phenomena will be presented from data obtained through studies with higher plants. Emphasis will be upon physiological variation that can be exploited in plant breeding.

**506 International Crop Breeding and Improvement**
Discussion of plant breeding principles and procedures that have been evolved and applied in breeding certain groups of crops, based on mode of pollination and the predominant type of gene action, as related to situations found in different parts of the world. Particular attention will be given to alternate approaches in breeding and crop improvement programs in developing countries and to cropping systems and agronomic practices which influence crop productivity. Reference materials and examples will be drawn from current activities in tropical agricultural regions. Student participation is expected.

**507 Research Orientation**
Designed to acquaint the student with the various facets of research in plant breeding. Particular attention will be given to the organizations engaged in plant breeding, sources and kinds of support, preparation of project outlines and reports, philosophies of selected past and present plant breeders, real and hypothetical research problems, varietal release procedures and policies, preparation of a publication, aids in presentation, and seeking a position.

**512 Experimental Methods**
Use of statistical methods and application of experimental designs and plot techniques to problems in plant breeding and related agricultural research.

**516 Advanced Topics in Plant Genetics and Breeding**
Study in depth of advanced research and other topics of special relevance to plant genetics and breeding. Examples of topics are: somatic hybridization, host-pathogen relationships, parameters of yield, mutation or radiation breeding, uses of male sterility, world germ-plasm resources, mass selection, plant competition and population dynamics.

**622 Seminar**

## Statistics and Biometry

**200 Statistics and the World We Live In**

**407 Introductory Computer Techniques for Statistics and Biology**
Introduction to computers, computing languages, and number representation. Preparation and running of computer programs using an elementary programming language; elementary statistical analyses, and techniques of sampling and simulation in statistics and biology.

**408 Probability and Statistics I**
Elementary probability, random variables, and probability distributions are considered. Biological and statistical applications serve to motivate the presentation.

**409 Probability and Statistics II**
The concepts developed in 408 are applied to provide an introduction to the theory of statistical inference; biological applications again serve to motivate the presentation.

**411 Stochastic Models in Biology**
An introduction to stochastic processes in biology. The necessary mathematics and statistics will be introduced as needed. Recurrent events, random walk models, Markovian processes, birth-and-death processes, epidemic processes, competition and predation, diffusion processes, and other models currently used in biological theory will be discussed and applied. Special emphasis will be given the various processes applied to genetics.

**412 Deterministic Models in Biology**
An introduction to deterministic mathematical models in biology. The application will be from the biological viewpoint. The necessary mathematics will be introduced as needed. Finite differences, differential equations, logistic, growth and decay, and other deterministic models corresponding to those introduced in 411 will be discussed.

**417 Matrix Algebra**
Basic matrix algebra with applications in biology, business, economics, and statistics. Arithmetic procedures and other matrix operations; rank and linear independence, latent roots and vectors, solving linear equa-

tions, generalized inverses, direct sums and products. Use of matrices in regression analysis and linear statistical models.

**499 Special Problems in Statistics and Biometry**

**510 Statistical Methods I**
The distributions of statistics encountered in biological and other fields are considered from the point of view of elementary probability notions and by sampling from known populations. The results, with principles of experimentation, are applied to the conduct of experiments and interpretation of results. Topics include point and interval estimation, tests of hypotheses and of significance, the treatment of discrete data, methods involving rank sum procedures, the consideration of normal populations, the one-way analysis of variance and simple linear regression. Emphasis is placed on basic statistical principles, criteria for selection of statistical techniques, and the application of these techniques to a wide variety of biological situations.

**511 Statistical Methods II**
The work of 510 is continued. Topics include multiple and curvilinear regression, complex analyses of variance and covariance. The analysis of variance discussion considers treatment designs, single degree of freedom contrasts, the simpler experimental designs, sampling errors, fixed, mixed and random models, and the effects of disproportionate numbers. When appropriate, the computer is considered as the reasonable way to have calculations done.

**513 Design of Experiments I**
Principles and techniques of experimentation; theoretical concepts; extension and variations of the completely randomized, randomized complete block, and latin square designs; the factorial experiment and confounding; fractional replication including response surface designs, lattice designs, cross-over designs, augmented and other designs; covariance analyses; error rates; test and interval estimation for ranked means; sample size; variance component analyses; unequal number analyses; the place of orthogonality in design; and advanced statistical methodology under various fixed, mixed, and random models.

**514 Design of Experiments II**
A continuation of the work in 513 with emphasis on the role of confounding in experimental and treatment designs. Generalized forms of analyses and construction are presented, followed by a discussion from selected topics on long-term experiments, combination of results from several experiments, sequential experimentation, variance component analyses, estimation procedures, linear hypotheses, heritability studies, multivariate analyses, unequal numbers analyses, and related topics.

**517 Linear Models**
Introduction to multinormal variables and distribution of quadratic forms; linear statistical models, estimable functions and testable hypotheses; regression models, experimental design models, variance components models, and combinations thereof.

**518 Selected Topics in Biometry**
Topics include the principles and methodology of bioassay, discriminant functions, sequential analysis, nonparametric methods, mark-recapture methods, and path analysis.

**520 Design of Experiments III**
A mathematical development of the properties, construction, and analysis of experiment and treatment designs. Proofs to be given for known results and problems to be formulated in mathematical terms.

# Plant Pathology

**301 General Plant Pathology**
An introductory course dealing with the nature, cause, and control of disease in plants. Representative diseases of cultivated crops are studied in the laboratory.

**309 Comparative Morphology of Fungi**
An introductory course in mycology. Emphasis is placed on morphology rather than taxonomy.

**501 Advanced Plant Pathology**
Designed to acquaint the student with the basic principles and techniques of the science of phytopathology and to provide an adequate foundation for research in this area.

**502 Principles of Plant Disease Control**
Emphasis is placed upon the philosophies underlying the principles of plant disease control. Objectives are to help students interested in plant protection equip themselves not only to apply existing methods and materials but to improve upon them by developing new ideas, especially in situations where control of plant diseases requires new approaches.

**505 Plant Virology**
Designed to provide advanced graduate students with basic information on the plant viruses and on the diseases they cause.

**506 Plant Nematology**
Anatomy, morphology, and taxonomy of plant parasitic forms and nonparasitic soil-inhabiting forms of nematodes are studied. Plant pathogenic forms also are considered from the standpoint of host-pathogen relationships, host ranges, life cycles, and the symptoms they cause. Principles and methods of control are discussed.

**507 Bacterial Plant Pathogens**
Designed to provide basic information on bacterial plant diseases and phytopathogenic bacteria. The laboratory will include some of the more important techniques used in study of bacterial plant pathogens.

**508 Disease and Pathogen Physiology**
Designed to provide students with insight into the mechanisms of pathogenesis and altered metabolism of diseased plants.

**521 Experimental Methods in Plant Pathology**
Designed to provide students with basic information on the application of statistical procedures and experimental designs in plant pathological research.

**531 Special Problems in Mycology or Plant Pathology**
In mycology, modern techniques and the experimental approach are stressed in areas such as physiology, developmental morphology, genetic systems, or cytotaxonomy. In plant pathology, for minor thesis or problems, or for students wishing to develop familiarity with modern techniques in some phase of the science.

**541 Philosophy of Plant Pathology**
Examination of the concepts of plant pathology as they relate to basic and applied research problems, teaching, and extension.

**556 Advanced Plant Nematology**
Students will conduct research projects in areas such as taxonomy, morphology, permanent mounting, soil and plant sampling procedures, procedures for extracting nematodes from soil and plant tissues, culturing, host-parasite relationships, relationships between nematodes and microorganisms, and evaluation of control practices. This research is intended to broaden training in plant nematology and thus the projects selected will not duplicate thesis research.

**579 Advanced Mycology**
A detailed study of the biology and taxonomy of the major groups of plant pathogenic fungi (rusts, smuts, Fungi Imperfecti, Peronosporales) with emphasis on mechanisms of variation in fungi. Optional field trips.

**599 Taxonomy of Fungi**
Emphasis is placed on the principles of taxonomy and nomenclature, critical evaluation of keys and monographs, and practice in identification. The Discomycetes, from which most examples are drawn, are treated in detail. Required field trips.

**645-654 Current Topics**
Weekly discussions of current topics in special areas of plant pathology and mycology. Students will be required to do extensive reading of current literature and to present oral and written reports.

**645 Plant Virology**

**646 Plant Nematology**

**647 Bacterial Plant Pathogens**

**648 Physiology of Plant Disease**

**649 Mycology**

**650 Diseases of Vegetable Crops**

**653 Pathology of Trees and Shrubs**

**654 Diseases of Florist Crops**

**655 Plant Diseases in Tropical Agricultural Development**

**656 Environment and Disease Development**

**661 Seminar**
Required of all graduate students taking work in the department.

**671 Plant Pathology Colloquium**

**Biological Sciences 498 Virology**

See also listings under the Field of Microbiology.

# Pomology

**101 Tree Fruits**

**102 Small Fruits**

**201 Postharvest Physiology, Handling, and Storage of Fruits**

**202 Advanced Laboratory Course**

**301 Economic Fruits of the World**

**401 Advanced Pomology**
A comprehensive study of the sources of knowledge and practices in pomology. The results of experience and research pertaining to pomology are discussed, with special reference to their application in the solution of problems in commercial fruit-growing.

**501 Special Topics in Experimental Pomology**
The student is expected to review critically and to evaluate the more important original papers relating to various phases of pomological research. Recent experimental methods applicable to the topic are fully considered.

**502 Research**

**504 Growth and Development of Woody Plants**
An advanced course dealing primarily with the growth and development of woody plants, with particular reference to fruit trees. Physiological responses will be emphasized, but morphological, cytological, and biochemical changes will be considered.

**600 Seminar**
Required of students taking 502, and graduate students in pomology.

# Psychology

**301 An Information Processing Approach to Psychology**
Introductory treatment of human behavior as the behavior of an information processing system. Topics covered include input and coding of information (detection and perception), storage and retrieval of information (learning and memory), and output processes (skill learning and performance). Also covered is a treatment of behavior as a choice among alternatives and the bases of such choices (motivation).

**305 Visual Perception**
The basic phenomena of visual perception studied in terms of the stimulus variables on which they depend and the mechanisms involved. Topics include detection of weak stimuli, perceptual constancy and illusion, visual space perception, motion, perceptual adaptation.

**306 Learning**
The fundamental conditions and principles of learning, both animal and human. Some phenomena of operant conditioning, descrimination learning, and verbal learning will be studied experimentally, and students will do individual projects. Traditional and contemporary theories of learning will be reviewed, and selected experimental literature will be discussed with special emphasis upon recent developments.

**307 Motivation**
Factors controlling the initiation, direction, and intensity of activitiy. Methods of research with emphasis upon experimental and statistical controls. Evaluation of evidence on major theories of motivation such as field theory, psychoanalysis, and behavioristic drive theory.

**309 Perceptual Learning and Development**
Current theories of perceptual learning in historical perspective; the development of perception and attention to objects, the spatial layout of the world, events and symbolic information in evolution and in human ontogeny.

**310 Human Learning and Memory**
Basic process of human learning and memory, particularly for simple verbal material. Emphasis on the storage and retrieval of information as the fundamental unit of learning.

**313 Cognitive Processes**
An examination of the so-called higher mental processes, including problem solving, chess, concept formation. The development of conceptual thinking in children, pathological thinking, and creative thinking will also be included. Students are required to carry out a small empirical study on some aspect of thinking.

**316 Auditory Perception**
The basic phenomena of auditory perception will be studied with emphasis on music and speech. Topics in the foundations of auditory perception including loudness, pitch, masking, binaural localization, and elementary neurophysiology of the auditory pathway will be followed by an examination of the perceptual bases of harmony, melody, and rhythm. Topics in speech include the rudiments of acoustic phonetics, natural and synthetic mechanisms of speech production, theories of speech perception, and auditory coding of sound.

**323 Physiological Psychology**
A selective examination of neural, endocrine, and biochemical functions related to emotion, memory, learning, and sleep.

**323A Physiological Psychology Laboratory**
Experiments will be done on physiological aspects of conditioning and memory in vertebrates and invertebrates, interactions between hormones and behavior, and effects of brain lesions on perceptual and alimentary behavior. A final original experiment will be planned and carried out.

**325 Abnormal Psychology**
An introduction to the study of disordered behavior. Description of major syndromes, investigations and theories of etiology, and approaches to treatment will be covered in an attempt to introduce the student to major concepts and problems in this area.

**326 Comparative Psychology**
Similarities and differences in the behavior of animals ranging from the unicellular forms to man. Psychological and ethological approaches to animal behavior will be discussed. Topics will include perception learning, communication, and social behavior, stressing both species-specific behavior and general trends in phylogeny.

**328 Behavioral Maturation**
Emergence of behavior will be studied in the light of developmental biology, including behavior genetics, neuroembryology and morphogenesis, physical maturation of the brain, transformation and allometry.

**350 Statistics and Research Design**
Devoted about equally to elementary applied statistics (both estimation and hypothesis testing) through two-way analysis of variance, and to general problems in the design and analysis of research projects.

**361 Drugs and Behavior**
Covers the techniques and problems in experimental psychopharmacology as they relate to psychoactive drugs as well as the behavioral, biochemical, and physiological effects of these drugs. Social and legal issues relating to the use of drugs in human societies will also be treated.

**381 Social Psychology**
Analysis of the history, concepts, methods, and theories used to describe and conceptualize the ways in which people react to one another in social settings and in the laboratory. Students will work individually or as teams on projects, using experimental or other empirical methods. The topics for lectures and reading will include socialization, attitude change, communication, interpersonal influence, impression formation, leadership, and propaganda.

**385 Theories of Personality**
A critical survey of the concept of personality in literature, the social sciences, and psychology. A number of the modern specialists will be discussed at some length, and recent empirical and experimental work that has grown out of their thought will be analyzed. The empirical relation of personality notions to some philosophical beliefs and literary production will be considered. The emphasis will be mainly upon "normal" personality.

**387 Psychological Aspects of Political Behavior**
A survey covering student activism, dogmatism, political paranoia, determinants of "left" and "right" ideology, Machiavellianism, autocratic vs. democratic leadership, need for power, group polarization and consensus, political socialization and psychocultural theories of war. An empirical, hypothesis-testing approach will be adopted.

**401 Psychological Testing I**
Emphasis is on the logical and mathematical problems in the interpretation, evaluation, and construction of tests. No training will be given in administering tests.

**402 Psychological Testing II**
A more advanced treatment of the topics discussed in Psychology 401.

**410 Individual Differences and Personality**
A selective survey of individual differences in personality, intelligence, creativity, psychopathology, learning, motivation, perception, and attitude change. Attention will be given to the conflict between experimental and correlational or observational research approaches. Related topics in the methodology of assessment will also be considered.

**415 Topics in Human Memory**
Consideration of advanced topics in human memory with emphasis on current theoretical issues. Subject-controlled processing strategies, the nature of mnemonic representation, forgetting, and retrieval will be covered.

**416 Psychology of Language**
Advanced treatment of the nature of the human capacity for language. Topics include nature of linguistic theory, semantics and reference, language universals, speech perception and production, comparative primate vocalization/communication, relationship of language to other cognitive processes, and the embodiment of language in the brain.

**423 Brain and Behavior**
A theoretical introduction to human neurology for psychologists. This survey of clinical symptoms and their etiology is designed to enable students to make use of knowledge of diseases for research purposes.

**426 Experimental Psychopathology**
The application of experimental methods to behavior disorders. A survey of current investigations of etiology and treatment with special emphasis upon a scientific approach to pathology.

**427 Sensory Function**
Sensory receptors and the central nervous system transformation of afferent activity will be considered in relation to human and nonhuman behavior and to the adaptive significance of behavior. The receptor will be examined in terms of anatomy, biochemistry, biophysics of transduction, and the central nervous system control of peripheral input.

**427A Sensory Function Laboratory**
Experiments on the principles of receptor function and afferent neural activity.

**429 Psychophysics and Scaling**
Emphasis on the theory and application of quantification procedures in psychology. Topics include measurement theory, psychophysical scaling procedures, signal detection theory, receptor sensitivity, auditory and visual discrimination, and multidimensional scaling methods.

**432 Social Psychological Aspects of Social Change**
A critical analysis of social psychological theories of social change. The development of social change theories and of the personality and social systems approach to understanding social change by examination of the utility of these approaches for understanding contemporary social phenomena.

**440 Sleep and Dreaming**
Investigation of animal and human biological, physiological, and psychological research on sleep and dreaming. Explores the relationship between physiological evidence, empirical laboratory research, and

clinical findings in the process and content of the dream state. Demonstrations of research techniques used in the animal and human sleep laboratory. Seminars will focus on reviews of the literature and research design and proposals.

**442 Physiological Mechanisms of Animal Social Behavior**
Examines the intricate relationships between environmental, behavioral, and physiological factors in the causation of social behaviors (e.g., sexual behavior, competition and aggression, maternal behavior, social organization). Hormone, neurohormonal, and brain functions related to these behaviors will be studied. The course will be broadly comparative and will cover both psychological and ethological approaches.

**462 Discrimination Learning**
Theories of discrimination learning will be examined in the light of data. Discrimination performance of human and nonhuman subjects in acquisition, reversal, transfer, and learning-set experiments will be included. Laboratory work will emphasize individual projects.

**464 Motivation and Human Learning**
Problems in the initiation and control of learning behavior. A review of classical and current learning theories with emphasis upon motivational constructs. A survey of research on intentional and unintentional learning, cognitive and noncognitive factors in conditioning, motivational factors in intellectual learning, motor skill, and memorizing.

**465 Mathematical Behavior Theory**
The purpose of this course is to give a brief overview of current developments in mathematical psychology and to develop techniques for the application of mathematics to psychological theory. Topics covered include choice behavior, decision theory, psychophysics, memory and learning theory, and information processing models of behavior.

**466 Theories of Vision**

**471, 472 Statistical Methods in Psychology**
An analysis of the methods for treating various kinds of psychological data. Fall term: methods of statistical inference; tests of significance and confidence limits, analysis of variance and correlation. Spring term: complex designs in analysis of variance, analysis of trends and covariance, multiple and curvilinear correlation, introduction to factor analysis.

**475 Analysis of Nonexperimental Data**
Introduction to techniques of data analysis especially applicable to nonexperimental situations. Multiple regression and its application to problems of unequal frequencies in analysis of variance and covariance; path analysis; factor analysis; general rational expressions; empathy and person perception; clinical vs. statistical prediction; Bayesian analysis; canonical analysis. Examples are drawn primarily from behavioral genetics; political behavior, cross-cultural studies, and nonlaboratory areas. Little emphasis on computational procedures since standard computer programs are used for most of the techniques discussed.

**476 Instrumentation for Psychological Research**
Principles and use of basic circuitry, digital logic, amplifiers and transducers, mechanical and optical devices, photography.

**481 Advanced Social Psychology**
Emphasizes empirical study of social psychological phenomena. Students will be introduced to empirical laboratory and field methods used in social psychology. Substantive problems will provide the focus for demonstration and use of these techniques.

**483 Social Interaction**
A field and laboratory course dealing with the major dimensions of interpersonal perception and behavior and their relation to self-conception, social roles, group structure and dynamics. Contemporary research is stressed in the readings. Student projects are an integral part of the course.

**484 Experimental Group Dynamics**
A practicum. Supervised research experience in the design, execution, and analysis of experimental research on topics such as group cohesiveness, group pressures, group goals, leadership, group performance, and interpersonal influence and communication.

**486 Groups as Socializing Agents**
The seminar examines critically existing theory and research on the role of groups in shaping the behavior and values of their members. Particular attention is focused on such processes as modeling, social reinforcement, and pressure to conform in enduring social structures such as the family, the peer group, work teams, and business organizations. Students are expected to work independently in assembling and evaluating material relevant to particular issues.

**489 Seminar: Selected Topics in Social Psychology**
A small discussion seminar dealing with issues in both social and personality psychology. Fall term: initial discussions will focus on specific areas such as interpersonal evaluation, attitude change, and group processes. Later, the discussions will become more general and raise such questions as: What are the major themes social psychologists should be studying? What are the appropriate units of analysis of social behavior? Spring term topics to be announced.

**490 Practicum in the Teaching of Psychology**
Intended to provide the student with first-hand experience in teaching psychology. Each student will enroll in the course for the spring or fall term during which time he will participate as a teaching assistant in an undergraduate course in psychology under the direction of a member of the faculty. Typically, these assistantships will involve responsibility for conducting a seminar or laboratory practicum, and it is expected that the student be proficient in the areas of psychology covered by the course.

**496 Supervised Study**

**497 Supervised Study**

**501, 502 General Seminar for Beginning Graduate Students**

**511, 512 Perception**

**513, 514 Learning**

**515, 516 Motivation**

**517, 518 Language and Thinking**

**521, 522 Psychobiology**

**523, 524 Physiological Psychology**

**525, 526 Mathematical Psychology**

**531, 532 History of Psychology**

**541, 542 Statistical Methods**

**543, 544 Psychological Tests**

**545, 546 Methods in Social Psychology**

**547, 548 Methods of Child Study**

**561, 562 Human Development and Behavior**

**575, 576 Personality**

**577, 578 Industrial Psychology**

**581, 582 Experimental Psychology**

**583, 584 Proseminar in Social Psychology**

**585 Social Structure and Personality**
A discussion seminar examining the impact of structural factors on personality development, and on the ways in which individual internal states and behavior patterns affect the functioning of social systems.

**591, 592 Educational Psychology**

**595, 596 The Teaching of Psychology**

**601, 602 Practicum in the Teaching of Psychology**

**611, 612 Practicum in Research**

**621, 622 Thesis Research**

**681, 682 Seminar in Social Psychology**
Research-oriented analysis of selected topics in social psychology.

**683 Research Practicum in Social Psychology**

**685 Seminar: Social Psychology of Modernization**
An analysis of the interacting effects of social structure and personality on social change in developing countries.

**Biological Sciences 320 Neurobiology and Behavior**

**Biological Sciences 421 Comparative Vertebrate Ethology**

# Romance Linguistics

## French

**401-402 History of the French Language**
Fall term: detailed study of the structural development of French from the origins to the Old French period. Spring term: selected readings in Old French texts, examination of structural changes from the Old French period to the present.

**403 Linguistic Structure of French**
A descriptive analysis of present-day French, with emphasis on its phonetics, phonemics, morphology, and syntax. Required of students seeking certification by New York State.

**404 French for Teachers**
Survey of the current teaching methods, preparation of teaching materials, selection and use of textbooks and realia, further study of phonetics, syntax, and culture as needed. Required of students seeking certification by New York State.

**429 Composition and Style**

**554 Gallo-Romance Dialectology**

**555 Historical Phonology of French**

**558 Linguistic Structures of Old and Middle French**

**600 Seminar in French Linguistics**

## Italian

**431 Structure of Italian**

**432 Italian Dialectology**

**433 Old Italian Texts**

**434 History of the Italian Language**

**600 Seminar in Italian Linguistics**

## Romance Linguistics

**441-442 History of the Romance Languages**
The history of the Romance languages as a whole from Latin times to the present and their interrelationships. A survey of the accomplishments and approaches of recent work in Romance linguistics.

**443-444 Comparative Romance Linguistics**
The family of Romance languages; the application of the comparative method and the reconstruction of Proto-Romance speech. The relation between Proto-Romance and Old and Classical Latin.

**445 Problems and Methods in Romance Linguistics**
Examination of selected samples of various methodologies in Romance linguistics, with reports and discussion.

**446 Romance Dialectology**
Examination of various types of dialectological description; study of overall relationship among Romance dialects.

**449 Areal Topics in Romance Linguistics**
Reading of texts and study of relationships of each area (Dalmatian, Rumanian, Provençal, Sardinian, Catalan).

## Spanish

**401 History of the Spanish Language**

**402 Old Spanish Texts**

**403 The Grammatical Structure of Spanish**
Descriptive analysis of the morphological and syntactical structure of present-day standard Spanish.

**404 Spanish for Teachers**
A course in methodology and applied linguistics for prospective teachers of the Spanish language. A survey of current attitudes, methods, materials, and techniques. The application of descriptive linguistics to the organization of lesson material, illustrated mainly through the contrastive study of Spanish and English phonology. Required for provisional New York State teacher certification.

**501 Linguistic Structures of Ibero-Romance**
A study in depth of one of the Iberian languages or dialects other than Castilian.

**502 Hispanic Dialectology**
The study of phonological, grammatical, and lexical variation in peninsular and American dialects of Spanish.

**503 Contemporary Theories of Spanish Phonology**

**504 Contemporary Theories of Spanish Grammar**

**600 Seminar in Ibero-Romance Linguistics**

# Romance Studies

## French

**309 Modes of the French Novel**

**361 Molière**

**362 Seventeenth- and Eighteenth-Century French Theater**

**388 Metamorphosis of the Modern Novel: Balzac to Beckett**

**390 Modernism**

**394 Literature/Structuralism**

**399 Varieties of the French Film**

**429 Stylistics**

**447 Medieval Literature**

**461 Corneille**

**466 LaFontaine**

**470 Pierre Bayle and Fontenelle**

**474 Rousseau**

**483 Narrative Problems of the Confessional Persona in Romantic Prose**

**488 Naturalism**

**539 Introduction to Philology**

**544 Seminar: The Old French Epic**

**548 Seminar: *Le Roman de la Rose***

**553 Seminar: Montaigne, Descartes, Pascal**

**555 Seminar: Ronsard and Du Bellay**

**556 Seminar: Music and Poetry in France: Late Middle Ages and Renaissance**

**560 Seminar: French Thought in the Seventeenth Century**

**576 Seminar: The Eighteenth-Century Novel in France, England, and Germany**

**579 Seminar: Marivaux**

**593 Seminar: Freud in France**

**597 Seminar: Proust**

**598 Seminar: Robbe-Grillet and Novelistic Criticism**

**599 Seminar: Don Juan as a Figure of Drama and Existential Man**

## Italian

**327 Dante: *La Divina Commedia***

**329 Early Italian Prose and Poetry**

**357 The Renaissance Epic Hero through Ariosto and Tasso**

**363 Modern Italian Poetry**

**385 The Nineteenth-Century Historical Novel**

**395 The Modern Novel**

**451 Sixteenth-Century Theater**

**474 Galileo to Vico: The New Science**

**485 Giovanni Verga**

**498 Poetry of Decadentism: Gabriele D'Annunzio**

**563 Seminar: Renaissance and Baroque Poetics**

**585 Seminar: Alessandro Manzoni**

**594 Seminar: Trends in Contemporary Criticism**

**595 Seminar: Italo Svevo**

## Spanish

**329 Spanish-American Literature to "Modernismo"**

**330 Spanish-American Literature from "Modernismo" to the Present**

**331 Twentieth-Century Spanish-American Drama**

**333 The Novel and the Mexican Revolution**

**336 The Modern Spanish-American Novel**

**338 Modern Spanish-American Poetry**

**389 The Generation of 1898**

**395 Form and Social Expression in the Post–Civil War Novel**

**413 The Epic**

**440 Medieval Literature**

**455 The Picaresque Novel**

**462 Golden Age Drama**

**465 Cervantes**

**468 Golden Age Poetry**

**469 Mysticism**

**480 Romanticism in Spain**

**482 Eighteenth- and Nineteenth-Century Spanish Drama**

**486 The Nineteenth-Century Spanish Novel**

**492 Contemporary Spanish Drama**

**530 Seminar: Latin American Literature: Borges and Mallea**

**541 Seminar: Golden Age Prose**

**594 Seminar: José Ortega y Gasset**

**595 Seminar: The Novels of Galdós**

**630 Proseminar: Principles of Esthetics and Literary Criticism**

# Semitic Studies

**311 Modern Hebrew Literature**
Selected readings from the major poetry and prose of Israel. Some attention will be given to the foundation of Hebrew literature in nineteenth-century Eastern European writings. Mendele, Bialik, and Agnon will be among the authors considered. A knowledge of Hebrew is desirable but not required; all readings will be available in English translation.

**320 The Emergence of Modern Judaism**
A study of the Reassessment of the Jewish Heritage by the foremost Jewish thinkers in modern times (from Spinoza to Buber). Readings from their works in English translation.

**409 Averroes and Averroism in Islam, Judaism, and Christianity**
Readings in translation of Averroes' writings on the soul and intellect, illustrative of that doctrine which came to symbolize the antithesis of traditional beliefs in personal immortality and in religious truth in general. Attention will be paid to the devastating effect Averroism had upon the development of the philosophical and scientific inquiry in Islam and Judaism, and to the reaction of Christianity to its challenge.

**410 Ethics and Mysticism in Judaism**
A study of ethical and mystical systems of thought in Jewish writings from late Hellenistic to contemporary times. Comparisons will be made wtih Gnostic, Islamic, and Christian writings, as well as with "normative" Rabbinic thought. Readings in translation from Kabbalistic and other medieval texts, as well as from Hasidic and modern authors such as Buber.

**432 Medieval Hebrew Literature**
Reading of a group of texts of philosophical interest.

**Studies in the Literature of the Old Testament (Comparative Literature 301)**
A critical appreciation of material (in translation) from

the following: Genesis, Exodus, Deuteronomy, Ruth, Samuel, Esther, Job, Proverbs, Ecclesiastes, and Jonah.

**Literary Studies in Christian Origins (Comparative Literature 303)**

**The Rational Tradition in Judaism (Comparative Literature 304)**

## Slavic Studies

This list excludes Russian language courses, which range from elementary to advanced, including special reading courses. These courses are listed in the *Announcement of the College of Arts and Sciences.*

**131S–132S Elementary Course in Slavic Languages**
In a given year one of the following languages will be offered according to demand: Serbo-Croatian, Bulgarian, Slovenian, Polish, or Czech.

**301–302 Advanced Russian Morphology and Syntax**

**314 Intellectual Background of Russian Literature, 1750–1900**
Rise of Romanticism, Slavophiles. Western influences. Conducted in English, but reading knowledge of Russian required.

**331 Russian Poetry**

**332 Russian Theater and Drama**
Survey of the history of the Russian drama from the eighteenth century to the present: Fonvizin, Griboedov, Gogol, Ostrovsky, and Chekhov. Soviet dramatists. Conducted in English, but reading knowledge of Russian required.

**369 Dostoevsky**
Reading of Dostoevsky's major works from *Poor Folk* to *The Brothers Karamazov.* Consideration of such problems as Dostoevsky's conception of good and evil, the structure of his novels, his importance for modern European literature. Reading in translation, but graduate students will do a portion of the reading in Russian.

**401–402 History of the Russian Language**

**403 Linguistic Structure of Russian**
A descriptive study and analysis of Russian linguistic structure. Russian phonetics, phonemics, morphology, and syntax.

**404 Russian for Teachers**

**421 Supervised Reading and Research**

**431 Russian Prose Fiction**

**432 Pushkin**

**435 Gogol**

**436 Turgenev and Other Prose Writers of His Time**

**501 Old Church Slavic**

**502 Old Russian**

**517 Russian Stylistics**
Literary uses of the Russian language. Close examination of texts from various periods and genres. Practical exercises.

**518 Russian Stylistics**

**520 Studies in Russian Poetry**
Extensive reading of nineteenth- and twentieth-century poets. Two or three poets to be selected for the class as a whole; each student to work privately on another poet of his choice. Reports, papers, readings of important critical works (such as Eikenbaum's *Melodika russkogo stikha*).

**521 Russian Literature from the Beginnings to 1700**
Representative works of Old Russian literature will be studied in the context of the cultural and artistic life of the times. Topics: the integration of the arts. Kievan Rus as participant in the pre-Renaissance. Representative genres. The creation of Muscovite culture. Polemical literature.

**522 Eighteenth-Century Literature**

**523 Early Nineteenth-Century Literature**
1800-1825: Early Russian romanticism, Zhukovskii, Batiushkov, Delvig, Baratynskii, Ryleev.

**524 Mid-Nineteenth-Century Literature**
Continuation of 523. Will cover period from 1825-1850. Emphasis on the journals and prose of the 1830's and 1840's. Belinskii, Lermontov, Nadezhdin, Vel'tman, V. F. Odoevskii, Polevoi, Zagoskin.

**528 Topics in Soviet Literature**
A survey of the major periods, figures, and movements of the Soviet period with emphasis on those theoretical and historical problems that are fundamental to the period as a whole. Early Soviet literature and prerevolutionary literary movements; the 1920's as an avant-garde period; ideological controversy and writers' groupings; the unnoticed 1930's; the place of émigré literature; the theory of socialist realism and the science of thaw measurement.

**534 Topics in Russian Symbolism**

**600 Seminar in Slavic Linguistics**

**601 Introduction to Graduate Study**
Required of all first-year graduate students majoring in Russian literature. Bibliography, methods of literary analysis, stylistics, topics in scholarship.

**603 Introduction to Slavic Linguistics**
Open only to graduate students majoring in Russian literature. Survey of basic concepts and current trends in linguistic theory; comparison of the basic structures of the Slavic languages.

**604 Seminar in Application of Linguistics to Analysis of Slavic Literatures**
Specific topics to be chosen according to the students' needs.

**611 Seminar in Russian Dialect Geography**

**671 Seminar in Twentieth-Century Russian Literature**

**672 Seminar in Nineteenth-Century Russian Literature**
Topic varies from year to year. May be repeated for credit.

**Comparative Literature 367 The Russian Novel**

**Comparative Literature 368 Soviet Literature**

**Comparative Literature 472 Origins of the Avant-Garde**

**Linguistics 561–562 Comparative Slavic Linguistics**

## Sociology

**402 Social Theory and Social Research**
Critical analyses of some recent publications in which dispassionate social scientific investigation of contemporary issues is attempted. Focus will be on empirical studies suggesting propositions of theoretical interest, in which the social scientist (as opposed to the social critic) investigates problems without having his own values of current fashions intrude on the selection of relevant data or interpretation of results. Each study

will be examined for stated and unstated assumptions, theoretical perspectives, concepts and operationalization of concepts, and empirical support for conclusions.

**420 Mathematical Sociology I**
Elementary mathematics as applied to sociological theory. Both deterministic and probabilistic models are considered. Stochastic probability processes are emphasized in relation to theories of social change.

**421 Mathematical Sociology II**
Models of social processes with particular attention to their relevance to social science research techniques. A detailed examination of James Coleman's book, *Mathematical Sociology*.

**425 Foundations of Statistical Analysis**
The logic of social research; sets and relations; measurement; probability models.

**433 International Urbanization**
An examination of the processes and prospects of urbanization in an international context. The growth, nature, and roles of urban centers in both developed and developing nations will be considered. Urbanization will be viewed from an interdisciplinary perspective.

**438 Human Migration**
An analysis of international and internal migration as it affects the social and economic structure of societies and the groups in movement. The major theoretical and methodological investigations will be examined from such varied perspectives as individual motivation and mathematical models of migration.

**441 Structure and Functioning of American Society I**
Systematic analysis of the major institutions of kinship, stratification, economic activity, political structure, education, and religion. Special attention is given to values and their interrelations in the modern social order. A survey of the more important types of groups and associations making up a pluralistic nation is included.

**442 Structure and Functioning of American Society II**
Primary attention is directed to the study of interrelation of institutions, including analysis of the regulation of economic and political systems. Group cooperation and conflict are surveyed. Analysis of important processes of change in institutions, values, and social organizations.

**447 Sociology of Health and Medicine**
An analysis of health, illness, and the health professions and institutions from the sociological perspective. Topics include social epidemiology, mortality and morbidity, the social psychology of illness, the socialization of health professionals, the organization of health care, and patient-professional relationships. Some attention will be directed to health and medical care in developing areas.

**462 Survey Research Methods**
After intensive review of current survey methods, students will design and carry out field projects, singly or in small groups. Substantive areas for research will vary from year to year.

**472 International Urbanization**
An examination of the processes and prospects of urbanization in an international context. The growth, nature, and roles of urban centers in both developed and developing nations will be considered. Urbanization will be viewed from an interdisciplinary perspective.

**480 Attitudes and Attitude Change**
A systematic survey of theory and research on attitudes and attitude change.

**481 Advanced Social Psychology (Psychology 481)**

**482 Social Psychological Aspects of Social Change**
A critical analysis of social psychological theories of social change. The development of a theory of social change. The evaluation of social change theories and of the personality and social systems approach to understanding of the utility of these approaches for understanding contemporary social phenomena.

**483 Social Interaction**
A field and laboratory course dealing with the major dimensions of interpersonal perception and behavior, and the relation to self-conception, social roles, group structure, and dynamics. Contemporary research is stressed in the readings. Student projects are an integral part of the course.

**484 Experimental Group Dynamics**
A practicum. Supervised experience in the design, execution, and analysis of experimental research on topics such as group cohesiveness, group pressure, group goals, leadership, group performance, and interpersonal influence and communication. Students will read and discuss experimental studies as well as pertinent theoretical articles.

**486 Groups as Socializing Agents (Psychology 486)**

**489 Seminar: Selected Topics in Social Psychology (Psychology 489)**

**491-492 Selected Topics in Sociology**

**503 Sociology of Science**
Examination of the relationships between the scientist and society, and of the effects of the scientist on society and of society on the scientist.

**522 Philosophy of Social Research**
Dialectical versus positivistic social research. The "value freedom" controversy. Objects of social analysis with implications for research strategies. A paradigm of the scientific process. Measurement, experimentation, and quasiexperimentation.

**523 Foundations of Statistical Analysis**
The logic of social research; sets and relations; measurement; probability models.

**524 Research Design and Statistical Inference**
The logic of statistical inference, experimentation, and decision theory. Measures of association for cross-classification. Causal analysis of multivariate relations, using regression analysis and related techniques.

**526 Mathematics of Human Mobility**
Deterministic and probabilistic models of mobility, emphasizing migration and social mobility. Stationary and nonstationary Markov processes are evaluated in detail as models of human mobility.

**528 Measurement and Latent Structure Theory**
The problem of index construction and classification is the focus for a study of factor analysis, latent structure analysis, and nonmetric multidimensional scaling procedures. Emphasis is on the logic of models and their relations to social theory and data. Computer routines will be used.

**530 Introduction to Social Demography**
A survey of the methods, theories, and problems of contemporary demography. Special attention is directed to the social determinants and consequences of fertility, mortality, and migration. The populations of both developed and developing areas are examined.

**531 Demographic Theory**
Deals with theory construction, hypothesis derivation, and the integration of theory and research in demog-

raphy. Although emphasis is placed on contemporary theories, earlier formulations beginning with Malthus also are examined insofar as they deal with fertility, mortality, migration, and the people-resource question.

**535 Techniques of Demographic Analysis**
Methods of processing and analyzing demographic data. Measures of mortality, fertility, and migration as applied to census and vital statistics data will be analyzed, and the more general applications of demographic techniques to other classes of data illustrated.

**536 Demographic Research Methods**
Application of basic demographic techniques to selected regions of the world, particularly those less developed economically. Attention is directed to field survey techniques, including sampling and questionnaire construction, as well as formal demographic analysis. Students may work on selected research projects.

**541 Social Organization and Change**
An analysis of major problems in theory and research in the general field of social organization and change. The subject will be studied from the standpoint of the nature and size of the social system (small groups, communities, large organizations, societies) and also in terms of its social processes and properties (integration, authority, conformity, and deviance).

**543 Family, Kinship, and Society**
A systematic analysis of the nuclear family, extended family systems, and corporate kinship groups cross-culturally and historically. The relations of family structures to other institutional areas; for example, economy, polity, stratification, and their relations to specific social processes such as demographic events, social disorganization, mobility.

**561 Sociology of Southeast Asia**

**583–584 Proseminar in Social Psychology**
Critical analysis of the major current theories and research, emphasizing sociological perspectives in the fall and psychological ones in the spring.

**602 Seminar: Social Theory**

**632 Seminar: Contemporary Research in Demography**
Critical analysis of recent research investigations in demography.

**641 Socialization of the Sociologist**
The course will utilize both institutional and social psychological perspectives. Among topics to be discussed: structure of American higher education; educational goals and norms; role requirements for sociologists as teachers and researchers; anticipatory socialization; rewards and punishments; criteria of "success" and "failure". Some topics will receive more attention from year to year depending upon the background and interests of the students.

**642 Seminar: Comprehensive Health Planning (Business and Public Administration 463 and Planning 789)**

**643 Seminar: Sociology of Medicine**
Selected topics in medical sociological research.

**647 Contemporary Research on Social Stratification**
Examination of selected key issues in current writing on social stratification.

**648 Issues in Latin American Development**
Each year a theme will be chosen that highlights a current issue in the social sciences related to the analysis of socioeconomic development in Latin America.

**657 Seminar: Social Change and the Community**
The seminar will concentrate upon the topics of leadership, religious organizations, and the process of social change.

**659 Seminar: Sociology of Adulthood and Aging**
The focus will be upon the latter half of the life cycle and will utilize both institutional and social psychological frameworks. Theory and research related to the following topics will be discussed: the middle aged and the elderly in relation to family, economy, and the polity: demographic trends and issues; social aspects of health; adult socialization; role changes and role crises. Emphasis will depend upon the background and interests of the students.

**662-663 Seminar: Social Systems Analysis**
Foundations of social systems analysis.

**671 Seminar: Urbanization**
An analysis of theories of urbanization and related aspects of social change. Comparative studies of urbanization will be evaluated in theoretical and methodological terms in order to make an evaluation of the current state of information in this subject area.

**672 Seminar: International Urbanization**

**681-682 Seminar in Social Psychology**
Research-oriented analysis of selected topics in social psychology.

**683 Research Practicum in Social Psychology**

**685 Seminar: Social Psychology of Modernization**
An analysis of the interacting effects of social structure and personality on social change in developing countries.

**691-692 Direct Research**

**Planning 712 Introduction to Human Ecology**

# Statistics

Descriptions of the following courses may be found under the Fields with which they are identified.

**Industrial and Labor Relations 310 Design of Sample Surveys**

**Industrial and Labor Relations 311 Statistics II**

**Industrial and Labor Relations 410 Techniques of Multivariate Analysis**

**Industrial and Labor Relations 411 Statistical Analysis of Qualitative Data**

**Industrial and Labor Relations 610 Economic and Social Statistics**

**Industrial and Labor Relations 614 Theory of Sampling**

**Mathematics 371 Basic Probability**

**Mathematics 472 Statistics**

**Mathematics 473 Statistics**

**Mathematics 571 Probability**

**Mathematics 572 Probability**

**Mathematics 574 Statistical Analysis**

**Mathematics 575 Information Theory**

**Mathematics 673 Analysis of Variance**

**Mathematics 674 Design of Experiments**

**Mathematics 675 Statistical Estimation**

**Mathematics 676 Decision Functions**

**Mathematics 677-678 Stochastic Processes**

**Operations Research 9460 Introduction to Probability Theory with Engineering Applications**

**Operations Research 9470 Introduction to Statistical Theory with Engineering Applications**

**Operations Research 9512 Statistical Methods in Quality and Reliability Control**

**Operations Research 9560 Applied Stochastic Processes**

**Operations Research 9561 Queuing Theory**

**Operations Research 9562 Inventory Theory**

**Operations Research 9565 Time Series Analysis**

**Operations Research 9570 Intermediate Engineering Statistics**

**Operations Research 9571 Design of Experiments**

**Operations Research 9572 Statistical Decision Theory**

**Operations Research 9573 Statistical Multiple-Decision Procedures**

**Plant Breeding and Biometry 411 Stochastic Models in Biology**

**Plant Breeding and Biometry 417 Matrix Algebra in Biology and Statistics**

**Plant Breeding and Biometry 510 Statistical Methods I**

**Plant Breeding and Biometry 511 Statistical Methods II**

**Plant Breeding and Biometry 513 Design of Experiments I**

**Plant Breeding and Biometry 514 Design of Experiments II**

**Plant Breeding and Biometry 517 Linear Models**

**Plant Breeding and Biometry 518 Special Topics in Biometry**

**Plant Breeding and Biometry 519 Statistical Genetics**

# Theatre Arts

**265 Voice and Speech for Performance**
A study of voice and speech variables and their nature when applied to theatrical performance. Emphasis is on ear training and the techniques of voice production to achieve precision of articulation, and to improve vocal range, resonance, and flexibility. Laboratory sessions supervised by the instructor include programmed self-instruction in general American and English phonetics, and work on individual voice and articulation problems.

**266 Voice and Speech for Performance**
Advanced voice and diction for the stage. Stage dialects studied through the combined approach of applied phonetics and ear training. Continued work in the techniques of voice production to improve range, resonance, and flexibility.

**285 Kinesthetics for the Theatre**
Flexibility and coordination exercises, posture and walk control, yoga as applied to theatre movement. Introduction to basic rules of body aesthetics, dietetics, and physiotherapy as applied to the performing arts.

**286 Kinesthetics for the Theatre**
Continuation of 285 with introduction to stage dueling and various techniques of weaponry and combat.

**333 History of the Theatre I**
A survey of the characteristics of primitive theatre and of theatrical styles and production modes in classical Greece, Rome, Medieval Europe, Renaissance England, and Spain.

**334 History of the Theatre II**
A survey of theatrical styles and production modes in Europe and the Orient since 1642. Among the areas considered will be Renaissance France, the English Restoration, the eighteenth and nineteenth centuries in England, France, Germany, and Japan, and the modern international stage.

**336–337 Survey of Theatrical Theory**
The development of the theory of the theatre in relation to theatrical practice. Fall term covers the period from the Greeks to the eighteenth century; spring term, the period from the eighteenth century to the present.

**348 Playwriting**
A laboratory for discussion of student plays. Each student is asked to write two or three one-act plays, or one full-length play.

**349 Advanced Playwriting**
A continuation of 348.

**361 Stagecraft**
A survey of technical problems of stage production. Lectures and demonstrations on theatre structure and equipment, scene construction and painting, stage lighting and equipment, costume construction, and technical drawing. Practice in scene and costume construction, painting, and lighting in both laboratory and actual productions.

**364-365 Stage Design I and II**
Stage scenery design from the specifics of mass, space, and color to the completed theatrical design. Laboratory work with the designer in rendering, scene painting, basic drafting, decor, and lighting.

**367-368 Costume Design I**
Stage costume design and construction. Practice in costume design, period research, and rendering techniques. Laboratory in practical costume construction.

**375 History of the Cinema I**
An introduction to the history and art of the cinema: its characteristic problems, devices, and development. Representative motion pictures will be studied. Lectures, demonstrations, and film viewings.

**376 History of the Cinema II**
An examination of the nonfiction film and the independent film. Attention is given to the film maker as artist, propagandist, and recorder. Representative examples will be studied. Lectures, demonstrations, and film viewings.

**377 Fundamentals of Cinematography**
Principles and methods of motion picture production with primary emphasis on creative techniques: script writing, photography, editing, special effects, and sound recording. Lectures, demonstrations, special projects.

**385-386 First-Year American Mime**
The actor is taught to create and perform symbolic activities in the mime form. Emphasis is on discipline, psychological preparation, mime acting, movement, and material.

**387-388 Second-Year American Mime**
Continuation of 385–386 with emphasis on directing,

design, and creative imagination. Creating and playing of scenes.

**438 Theatre Aesthetics**
The chief theories of dramatic production in relation to aesthetic principles.

**465-466 Graduate Voice and Speech for Performance**
Emphasis on vocal interpretation of roles. Use of special skills and vocal technique in building character and interpreting roles.

**467 Advanced Costume Design**
Projects in stage costume design and rendering techniques. Emphasis on design of total production.

**468 Advanced Costume Construction**
Projects in application of historical patterning for the stage.

**475 Seminar in the Cinema**
Selected topics in the history and aesthetics of the cinema.

**480 Graduate Acting**
The study and practice of fundamental and advanced technique and methodology. May be repeated for credit.

**498 Advanced Directing**
Investigation of the theatrical meaning of a play and the methods by which such meaning may be communicated in the modern theatre. Discussion and studio practice.

**499 Projects in Directing**
The planning and execution of directing projects by advanced students in the public facilities of the Theatre Arts Department.

**500 Introduction to Research and Bibliography in Theatre Arts**
A study of methods and materials relevant to the solution of problems in theatre arts including introduction to standard research sources, problems of translation, and preparation of theses and publications.

**536 Seminar in Dramatic Criticism**
Selected theories of the drama from Aristotle to the present.

**538 Seminar in Theatre Aesthetics**

**599 Seminar in Theories of Directing**
A study of the theory and practice of significant directors in theatre history. An examination of directorial interpretation and theatrical realization, with consideration of the social, philosophical, and cultural milieu in which the directors worked.

**690 Theses and Special Problems in Drama and the Theatre**

See also the Field of Comparative Literature and other Fields with offerings in literature.

# Theoretical and Applied Mechanics

## Engineering Mathematics

**1126, 1127 Mathematical Concepts in Science and Technology**
Intended to encourage study of modern abstract mathematics and its relationship to science and technology. Considers various applied problems and methods from the standpoint of underlying abstract mathematical similarity and follows with an introductory treatment of unifying concepts from modern analysis and algebra. Topics will include: the real-complex embedding and its significance for the theory of power series, linear differential equations, and operational (transform) calculus; the theory of contraction mappings on metric spaces and its relation to various iterative solution techniques and existence-uniqueness questions; spectral theory of symmetric linear operators on Hilbert spaces and their connections with matrix diagonalization and boundary value problems; the theory of constrained minimization of functionals on a Banach space and its relation to optimal control and programming problems. Physical motivation will be drawn from a variety of sources, historical and current, including the literature of theoretical mechanics, communication and control theory, and numerical analysis.

**1180 Methods of Applied Mathematics I**
Ordinary differential equations; series; orthogonal functions and Sturm-Liouville theory; functions of several real variables; vector fields and integral theorems; matrices; partial differential equations. The course emphasizes applications and techniques of solutions, wherever possible, and is intended for students who plan to use applied mathematics frequently. At the level of *Mathematics of Physics and Modern Engineering* by Sokolnikoff and Redheffer.

**1181 Methods of Applied Mathematics II**
Continuation of partial differential equations; Green's function; Fourier and Laplace transforms; complex variables; calculus of variations; tensor analysis.

**1182 Methods of Applied Mathematics III**
Application of advanced mathematical techniques to engineering problems. Conformal mapping; complex integral calculus; Green's function; integral transforms; asymptotics including steepest descent and stationary phase; Wiener-Hopf technique; general theory of characteristics; perturbation methods; singular perturbations including PLK method and boundary layers. Development will be in terms of problems drawn from vibrations and acoustics, fluid mechanics and elasticity, heat transfer, electromagnetics.

**1183 Methods of Applied Mathematics IV**
More extensive treatment of 1182 in same spirit. Topics include: method of matched asymptotic expansions. W.K.B. approximation; Hilbert-Schmidt and Fredholm theories of integral equations; singular integral equations. Wiener-Hopf equations with application to finite interval. Carleman equation and its generalization, effective approximations; further methods in partial differential equations, slot problems.

**1184 Numerical Methods in Engineering**
Methods for obtaining numerical solutions to problems arising in engineering. Linear and nonlinear mechanical systems. Ordinary and partial differential equations, initial value problems, boundary value problems, eigenvalue problems and extrema. Calculus of variations. Function-space methods. Applications to vibrations, diffusion, heat transfer, wave propagation, membranes, plates, fluid flow, and celestial mechanics. Simulation of dynamical systems. Analog computation.

## Mechanics of Solids

**1263 Applied Elasticity**
Analysis of thin curved bars. Plane stress and plane strain in the circular cylinder, effects of pressure, rotation, and thermal stress. Small and large deflection theory of plates, classical and approximate methods. Strain energy methods. Symmetrically loaded thin cylindrical shell. Torsion of thin-walled members. A first

course in the mechanics of elastic deformable bodies with structural applications.

**1264 Theory of Elasticity**
General analysis of stress and strain. Plane stress and strain. Airy's stress function solutions using Fourier series, Fourier integral, and approximate methods. St. Venant and Mitchell torsion theory. Simple three-dimensional solutions. Bending of prismatical bars. Axially loaded circular cylinder and half space.

**1265 Mathematical Theory of Elasticity**
Development in tensor form of the basic equations of large deformation elasticity; solution of certain large deformation problems. Linearization to infinitesimal elasticity. Boussinesq-Papkovich potentials and their application to three-dimensional problems; contact problems; plane stress by method of Muskhelishvili; application of conformal mapping; Couchy integral techniques in elasticity, torsion problems.

**1267 Introduction to the Inelastic Behavior of Solids and Structures**
Introduction to the physical aspects of inelastic material behavior. Idealized models for microscopic analysis of elastic, plastic, viscous, viscoplastic and locking materials. Mathematical formulations and methods of solution. Design concepts.

**1268 Theory of Plasticity**
Theory of inelastic behavior of materials. Plastic stress-strain laws, yield criteria, and flow laws. Flexure and torsion of bars, thick-walled cylinders, metal forming and extrusion, stress analysis in metals and soils. Limit analysis of beams, plates and shells. Shakedown. Selected topics in dynamic plasticity.

**1269 Thermal Stresses**
A treatment of the behavior of solids and structures at elevated temperatures. Thermomechanical coupling, inertia effects. Review of heat conduction in solids. Thermally induced vibrations. Elastic and inelastic stress analysis. Thermal buckling.

**1270 Energy Methods in Solid Mechanics**
A study of the various energy methods used in structural analysis. Principle of virtual work. Strain energy and complementary energy theorems. Reciprocal theorems. Elastic and inelastic analyses. Dynamical problems. Energy stability criteria.

**1280 Composite Materials (Materials Science and Engineering 6625)**
The physical basis of the strength, elastic modulus, and fracture resistance of composite materials; the micro- and macro-mechanics of composites, their mechanical response, and important composite systems including fabrication, processing, and design applications. Compatibility and interaction of fibers and matrix. Fatigue, creep, fracture mechanisms. Analysis of primary configurations such as tension and compression members, beams, and plates including such local effects as bonding, fiber-tip stress concentration, buckling.

**1290 Continuum Mechanics and Thermodynamics**
Kinematics. Conservation laws. The entropy inequality. Constitutive equations. Frame indifference. Material symmetry. Simple materials and the position of the classical theories in the framework of modern continuum mechanics.

**1291 Continuum Mechanics and Thermodynamics of Solids**
Theory of (nonlinear) elasticity and thermoelasticity: universal solutions, wave propagation, stability theory. Nonlinear viscoelasticity and introduction to more general theories of solids.

**1292 Continuum Mechanics and Thermodynamics of Fluids**
Viscometric flows of non-Newtonian fluids. Theory of mixtures. Oriented media and the theory of liquid crystals.

## Dynamics and Vibrations

**1362 Vibration of Elastic Systems**
Review of virbration of linear lumped systems with emphasis on matrix and transient phenomena. Free and forced vibration of continuous systems, including strings, rods, beams, membranes, and plates. Waves in rods and beams. Orthogonality conditions and application of generalized functions. Rayleigh-Ritz method. Mathieu function and dynamic instability of strings, columns and other elastic systems. Nonlinear phenomena.

**1366 Stress Waves in Solids**
General equations of elastodynamics. Waves in extended elastic media. Reflection and refraction of waves. Surface waves and waves in layered media. Vibrations and waves in strings, rods, beams, and plates. Dispersion in mechanical wave-guides. Transient loads. Scattering of elastic waves and dynamical stress concentration. Waves in anisotropic media and viscoelastic media.

**1370 Intermediate Dynamics**
Newtonian mechanics for single particles and systems of particles, conservation laws, central force motion; rigid body mechanics, Euler's equations, tops, gyroscopes; generalized coordinates, introduction to Lagrangian mechanics, Hamilton's principle; small oscillations. At the level of McCusky, *Introduction to Advanced Dynamics.*

**1371 Advanced Dynamics**
Lagrangian mechanics, principle of least action, Hamilton's principle; Hamilton's canonical equations of motion, Hamilton-Jacobi theory, perturbation theory, quantum mechanics, special relativity.

**1375 Nonlinear Vibrations**
Phase plane techniques, singular points, conservative systems, limit cycles, Poincaré-Bendixson theorem, Poincaré's cycles without contact, method of isoclines, Lienard's method, Lyapunov stability, Floquet theory, Hill's and Mathieu's equation, perturbation methods, method of Krylov and Bogoliubov. Emphasis on applications throughout.

**1376 Stability of Motion**
Physical notions of stability, Lyapunov stability, orbital stability, Lyapunov's second method, validity of linearized variational equations, stability of equilibrium points, stability of periodic motions, Floquet theory, perturbations, structural stability, stability of motions governed by partial differential equations, Poisson stability, ergodicity.

**1381 Dynamics of Flight**
Introduction to the dynamics of atmospheric vehicles. Static stability and control. Derivation of the general equations of unsteady motion. Small disturbance equations. Dynamic stability. Dynamic response to controls. Stability augmentation and automatic control. Flight path optimization techniques. At the level of Etkin, *Dynamics of Flight.*

## Experimental Mechanics

**1459 Experimental Mechanics**
The student selects four to six experiments to meet his individual interests. Available experiments include: elastic waves in rods, viscoelastic waves and internal damping, linear vibrations of beams and plates,

nonlinear response of elastic plates; two- and three-dimensional photoelasticity; plastic response of structures; magnetoelastic buckling of a beam-plate; gyroscopic motion; linear oscillators and analog computers.

**1460 Experimental Mechanics**
The student chooses two to three "in-depth" experiments from areas very active in contemporary experimental mechanics and reflecting some of the research interests of the faculty. Experiments utilizing holographic interferometry techniques and internal friction techniques are now planned.

## Space Mechanics and Aerospace Structures

**1730 Transportation Structures I**
Evolution of aerospace structural design concepts and the structural design cycle. Environmental, structural design inertia, and specifications for aircraft, missiles, and spacecraft. Inertia loads, load factors, flight envelopes, gust loads. Aerodynamic and solar heating, loads in space flight. Materials of construction and their properties; elastic and inelastic behavior, fatigue. Theories of failure. Fracture mechanics. Elementary structural analysis.

**1731 Transportation Structures II**
Structural problems and configurations of aircraft, missiles, and spacecraft. Analysis and design of thin-walled members in bending, torsion, and combined loadings, Reinforced stressed skin construction, thick shell construction, sandwich and composite materials. Inelastic analyses; plastic and viscoelastic behavior. Buckling, torsional instability, and crippling of thin-walled beams; creep buckling. Buckling and postbuckling behavior of plates, effective width. Thermal stresses and high temperature effects.

**1772 Space Flight Mechanics**
Gravitational potential of the earth; two-body problem; three-body problem; restricted three-body problem; Jacob's integral; Hill curves; libration points and stability. Lagrange's planetary equations; effect of oblate earth, atmospheric drag and solar radiation on satellite orbits; satellite attitude control; orbital transfer and orbital maneuvers; rendezvous problems.

**1773 Mechanics of the Solar System**
Applies the principles of mechanics (mainly dynamics but also elasticity) to explain some large-scale physical phenomena in the solar system. An understanding of the interplanetary environment will also be developed during the course. Topics include: seismic waves and free oscillations of the earth; gravitational potential of planets and their rotation; tidal interactions and Roche's limit; dynamics of the earth-moon system; spin-orbit coupling for Mercury and Venus; dynamics of comets, interplanetary dust and energetic charged particles; perihelion percession of Mercury; theories of the origin of the solar system.

**1774 Trajectory Optimization**
Review of calculus of variations. Optimal impulsive trajectories. Maximum principle, bounded controls, singular arcs and bounded state variables. Numerical methods, gradient techniques, quasilinearization. Applications to minimum time and minimum fuel orbit transfer, rendezvous, and interplanetary trajectories.

**1892 Current Research Problems in Bionics and Robots**
A graduate-level seminar, concentrating on a few topics in biomechanics, bioengineering, bionics, and robots at some depth. Students will give oral presentations on current research, and faculty and students will report on current research literature and personal investigations in such areas as: robots to learn natural language; artificial intelligence; pattern recognition and scene analysis by machine; adaptive control; brain and behavior models.

## Special Courses

**1904, 1905 Seminar in Fluid Mechanics**
Study and discussion of topics of current research interest in fluid mechanics. Participants deliver reports based on published and unpublished literature.

**1921, 1922 Project in Mechanics**
A minimum of three credit hours must be completed by each candidate for the Master of Engineering (Engineering Mechanics) degree.

**1996 Research in Theoretical and Applied Mechanics**
Thesis, literature survey, or independent research under the guidance of a staff member.

**1997 Selected Topics in Theoretical and Applied Mechanics**
Special lectures or seminars on subjects of interest; topics will be announced.

# Vegetable Crops

**401 Vegetable Crops Physiology**
The physiological bases of cultural practice and the application of these principles to problems in vegetable production. Original literature is used to illustrate the principles involved. Experimental material is studied in the laboratory to amplify lecture topics. Subjects discussed include: mineral nutrition as influenced by fertilization programs and crop sequence; nutrient interactions and induced deficiencies; growth and development; flowering; fruit setting; growth correlation; senescence; sex expression; photoperiodism; vernalization; and environmental factors affecting growth.

**413 Kinds and Varieties of Vegetables**

**429 Special Topics in Plant Science Extension**
Designed for students in plant science who wish to acquire a knowledge of extension activities in preparation for careers in extension and associated work, such as research and technical work in both public and commercial organization. Topics are related to extension in other countries as well as in the United States.

**501 Research Methods in Applied Plant Science**
The planning of research programs as influenced by various economic, administrative, political, and geographic environments. The advantages and limitations of conventional experimental designs as they apply to specific research problems. Discussions include a critical interpretation of experimental results from the literature. Many topics are directly applicable to the student's thesis research.

**601 Seminar**
Required of graduate students taking either a major or minor in this Field.

**610 Special Topics in Vegetable Crops**
Weekly discussions of current topics in plant physiology as related to vegetable crops. Students will be required to present oral reports on current literature and to prepare and present a research proposal.

# Veterinary Medicine

## Anatomy

**505 Neuroanatomy**
The structure and function of the nervous system of domestic animals are studied by functional systems. Clinical cases with pertinent lesions are demonstrated with each system.

**507 Developmental Anatomy and Histology**
The study of development is designed to provide a foundation for the understanding of definitive anatomy and the formation of anomalies. The latter part of the course is devoted to cytology and histology, illustrated with material from domestic animals.

**508 Microscopic Anatomy**
The microscopic structure of the tissues and organs of domestic animals is studied. Illustrated lectures relate structure to function, correlate microscopic and gross anatomy, and establish a foundation for subsequent studies in physiology and pathology. Slides of tissues and organs are provided.

**605, 606 Advanced Anatomy**
Advanced study under personal direction.

**900 Vertebrate Morphology**
Designed for graduate students in animal science, nutrition, and conservation. A dissection of the dog serves as the basis for a functional consideration of the component parts of mammalian organ systems. This is followed by a discussion of the fetal and adult cow, and other species of interest.

**901 Comparative Anatomy of the Digestive Tract**
A general knowledge of the gross anatomy of each organ will be assumed, and emphasis will be placed on the micro-macroscopic muscular and vascular architecture, innervation, and functional cytology of the epithelium.

## Avian Diseases

**750 Diseases of Poultry**
Diseases of domestic poultry and other birds are studied with special emphasis on differential diagnosis and control. Fresh and preserved specimens from the Poultry Diagnosis Clinic are presented during the laboratory period.

## Large Animal Medicine, Obstetrics, and Surgery

**636 Clinical Pathology**
The application of the techniques of hematology, urinalysis, cytology, semen examinations, and other laboratory procedures in diagnosis; the biochemical changes in the blood and other fluids in disease; the study of pathological alterations in clinical cases.

**740 Epidemiological Methods**
A lecture course dealing with health and disease from a herd, flock, community, or population standpoint and emphasizing the use of knowledge about etiology, transmission, and distribution of disease in the development of preventive and control measures.

**938 Reproductive Pathology**
This is an advanced course in reproductive pathology of both male and female domestic animals with equal emphasis on gross and microscopic lesions of their genital tracts.

**970, 971 Advanced Work in Reproductive Pathology and Bacteriology, Medicine, Obstetrics, and Surgery**
Properly prepared students may undertake special problems or receive special assignments in the field of reproductive pathology, microbiology, equine nutrition, medicine, obstetrics, and surgery.

**972 Urogenital Surgery of the Horse**
Surgical diseases of the urogenital system of the mare and stallion. Lectures will be in seminar-discussion form. The anatomy laboratory will utilize the prosected specimens and video-tape, in collaboration with the Anatomy Department. The surgical pathology laboratories will also utilize cadaver dissections.

**973 Surgery of the Digestive System of the Horse**
Surgical diseases of the digestive system including the oral cavity, pharynx and esophagus, and gastrointestinal tract. Special consideration of problems arising from diseased teeth and obstructive disease of the esophagus and intestine. Laparotomy techniques will be covered in depth. Lectures will be in seminar-discussion form: Laboratories will employ dissected specimens. Presented in collaboration with the Anatomy Department and the Pathology Department.

See also 670 Fundamentals of Roentgenology, 671, 770 Obstetrics and Genital Diseases, 771, 772, 870, 871 Diseases of Large Animals, 773, 774, 775 General and Special Surgery and Surgical Exercises, 872 Jurisprudence, Ethics, and Business Methods in the *Announcement of the New York State Veterinary College.*

## Microbiology

**340 Pathogenic Bacteriology**
Includes microbiology, virology, and immunology.

**740 Epidemiological Methods**

**741 Infectious Diseases**
Infectious diseases of domestic animals, with attention to the zoonoses.

**941 Advanced Immunology Lectures**
Complement fixation, conglutination complement absorption, hemagglutination inhibition, precipitation, fluorescent antibody techniques, neonatal isoerythrolysis, and antigenic analysis of *Salmonella* cultures.

**942 Advanced Immunology Laboratory**
Lecture topics include quantitative aspects of the antibody-antigen reaction, physical and chemical properties of antibodies and antigens, the mechanisms of hypersensitivity, and tissue immunity. Laboratory experiments illustrate the phenomena covered in the lectures and familiarize the student with selected immunochemical techniques.

**943, 944 Advanced Work in Bacteriology, Virology, or Immunology**
Special problems or special assignments for properly prepared students.

**945 Animal Virology and Tissue Culture Methods**
Lectures will include the biology of animal viruses with emphasis on topics of general significance. Laboratory exercises emphasize methods of tissue culture preservation of cell lines, and the application of tissue culture methods to virology.

**946 Microbiology Seminar**

**947, 948 Laboratory Methods of Diagnosis**
Instruction and practice in the application of bacteriological and serological methods for the diagnosis of disease.

## Pathology

**630 General Pathology Lectures**
The biological processes involved in various kinds of disease are studied. This includes degenerative, circulatory, and inflammatory diseases, as well as a consideration in depth of the causes and manifestations of cancer.

**631 General Pathology Laboratory**
Covers the same subject matter as 630.

**632 Special Pathology Lectures**
Systematic study of diseases of each body system—respiratory, urogenital, skeletal, etc.

**633 Special Pathology Laboratory**
Accompanies 632.

**635 Animal Parasitology**
A systematic study of the helminth and arthopod parasites of domestic animals, with particular emphasis on identification and bionomics of forms of veterinary importance.

**731 Applied Parasitology**
An organized study of the parasitic diseases of domestic animals, with particular emphasis on the features of diagnostic importance. Special attention to laboratory and postmortem techniques of value in applied parasitology.

**930 Pathology Seminar**
Required of all graduate students in pathology.

**931 Pathology of Nutritional Diseases**
Lecture and laboratory on the macro-microscopic anatomy of various spontaneous and experimental nutritional diseases.

**932, 933 Advanced Work in Animal Parasitology**
Special problems concerning the parasites of domestic animals.

**936, 937 Advanced Work in Pathology**
Special problems or special assignments for properly prepared students.

**938 Reproductive Pathology**

**939 Introduction to Laboratory Animal Medicine**
A graduate course designed primarily to emphasize the use of laboratory animals as tools in biological research. Dogs, cats, mice, rats, guinea pigs, hamsters, rabbits, nonhuman primates, poultry and several unusual species will be considered. The course will provide an introduction to management and disease control, as well as information on certain aspects of the comparative anatomy, ecology, behavior, and genetics of these animals.

**940 Ultrastructural Pathology**
Study is directed toward development of capability in interpretation of electron micrographs of biological structures in health and disease. Techniques of electron microscopy of biological material will be briefly reviewed. The major part of the course will be directed toward alterations of specific organelles and subcellular systems in pathologic processes, such as inflammation and neoplasia, and the ultrastructural pathology of selected organ systems, e.g., kidney, blood, vasculature, and liver.

## Physical Biology

**921 Radioisotopes in Biological Research—Principles and Practice**
Lectures, demonstrations, and laboratory on the fundamentals of atomic energy procedures and applications to biological research.

**922 Biological Effects of Radiation**
Lectures and demonstrations on radiation physics, radiation chemistry, radiation effects at the cellular level, radiation effects in multicellular organisms, genetic effects of radiation, and radioprotective and radiomimetic substances.

**923 Biological Membranes and Nutrient Transfer**
An introduction to elementary biophysical properties of biological membranes, theoretical aspects of permeability and transport, and mechanism of transfer of inorganic and organic substances across intestine, placenta, kidney, erythrocytes, bacteria, and other biological systems.

**924 Functional Organization of the Nervous System**
Function of the nervous system will be considered primarily from an electrophysiological viewpoint. Where appropriate, important studies of reflexology, chemical and feedback control, and comparative anatomy will be utilized. Laboratory studies will include electrical activity of cells, reflexes, decerebrate rigidity, acoustic microphonic response, subcortical stimulation, and evoked and spontaneous cortical activity.

**925 Physiology, Biochemistry, and Biophysics of Mineralized Tissue (Special Topics)**
Introduction to the histology, anatomy, and pathology of bones and teeth, kinetics of bone and bone minerals, biochemistry of calcification, factors affecting calcium and bone metabolism (parathyroid hormone, calcitonin, vitamin D, trace elements, etc.), bone-seeking radionuclides, and calcium homeostatic mechanisms.

**926 Physical Biology Graduate Seminar**

**927 Special Topics in Physical and Radiation Biology**

**928 Experimental Physiology for Graduate Students**

See also Physiology 427.

## Physiology, Biochemistry, and Pharmacology

**511 Physiology**
Physiology of cells, muscle, nerve, nervous system, digestive system, urine secretion, and temperature regulation.

**610 Physiology**
Physiology of blood, lymph, circulation, respiration, endocrine organs, and reproduction.

**612 Pharmacology**
Primary emphasis is on the physiological disposition and mechanism of action of drugs.

**613 Toxicology**

**910, 911 Special Problems in Physiology**

**912, 913 Research**

**915 Methods in Physiological Research**
The course will emphasize principles and application of physiological methods for measurement of organ and tissue functions related to digestion, absorption, distribution, metabolism, and excretion.

**916 Physiological Disposition of Drugs and Poisons**
Lectures on the absorption, distribution, metabolism, excretion, and selective toxicity of drugs as well as consideration of environmental aspects of the problem of toxicology.

**917 Physiology**
Lectures and demonstrations on cellular physiology,

muscle, nervous system, digestive system, urine secretion, blood and lymph. (For laboratory, register for 928.)

**918 Physiology**
Lectures and demonstrations on circulation, respiration, endocrine organs, temperature regulation, and reproduction.

**919 Comparative Gastroenterology**
Lectures will emphasize 1) functional comparison of digestion and absorption in the carnivore, omnivore, and herbivore in mamalian and avian species, 2) examination of various in vivo and in vitro preparations and procedures used to study the function or malfunction in this system, and 3) digestive tract diseases.

## Small Animal Medicine and Surgery

Basic courses in general and advanced canine medicine, general canine surgery, canine orthopedic surgery, canine thoracic surgery, canine ophthalmology, and breeding diseases of small animals are available, and advanced work will be given on an assignment basis.

# Zoology

Courses of graduate interest may be found throughout the University. For examples in biological sciences, consult other biological Fields in this *Announcement* or in the *Announcement of the College of Agriculture.*