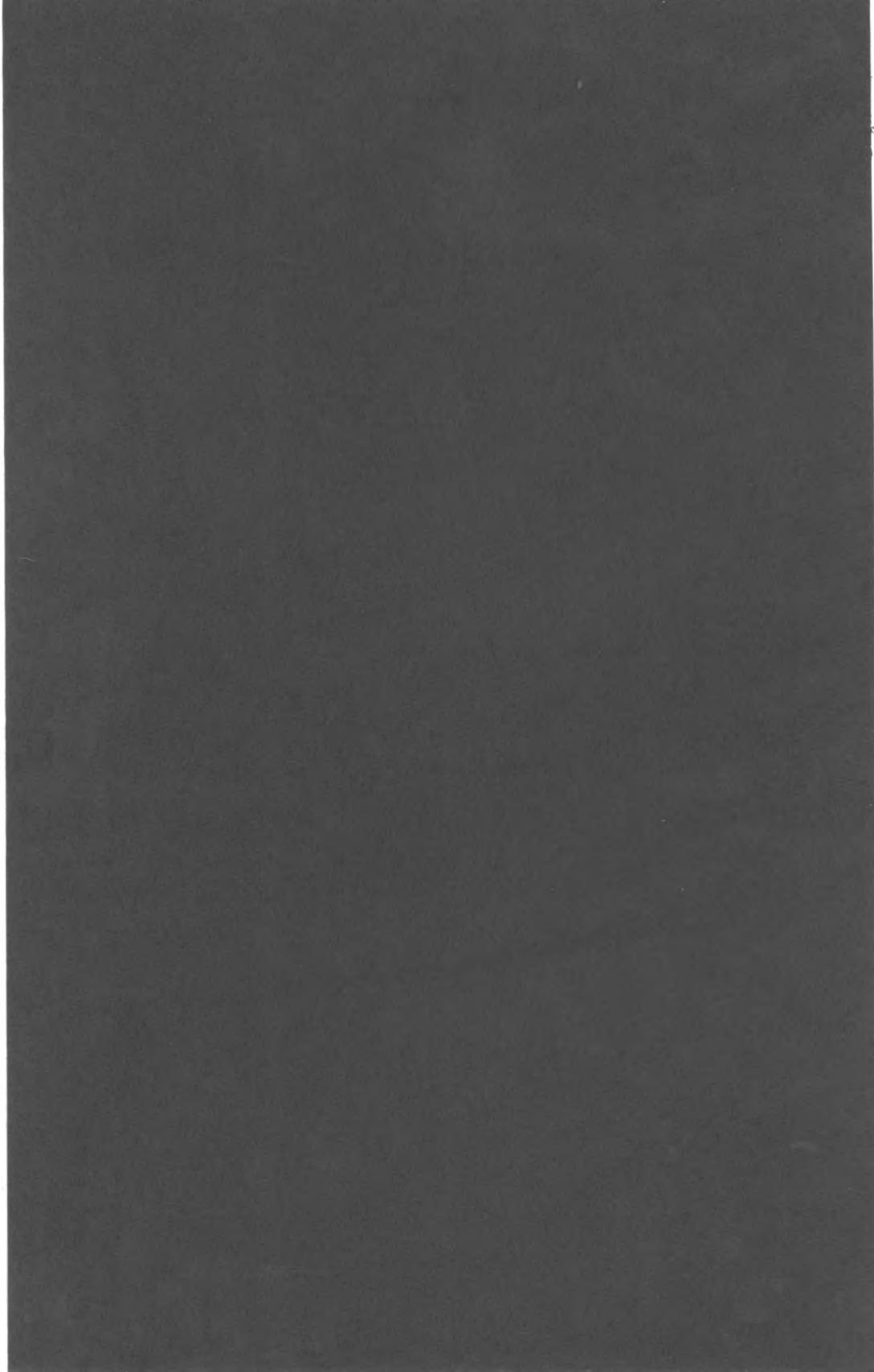




Cornell University  
Announcements

Graduate School  
Course Descriptions



Cornell University

Graduate School:  
Course Descriptions

1974-76

**Cornell University Announcements**

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**Announcement**

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The courses and curricula described in this *Announcement*, and the teaching personnel listed herein, are subject to change at any time by official action of Cornell University.

## 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 *Announcements*, or the Course and Room Roster issued by the registrar each term). Not all courses are offered every year. A complete list of *Announcements* may be found at the back of this publication.

A new numbering system has been instituted. Those numbers which appear in parentheses in the following pages are the old numbers.

## Aerospace Engineering

See also listings under Mechanical Engineering, particularly those prefixed by MF, MH, MP, MT

### MA602 (7302) Theoretical Aerodynamics I.

Laplace's equation. Source, sink and doublet. Vortices. Biot-Savart theorem, flow field of a vortex. Spherical and cylindrical harmonics. Methods of singularity distributions. Complex-variable methods. Wing theory. Acoustics. Compressible flows, subsonic and supersonic. Shock waves. Hypersonic flow. Rotational flows. Magnetohydrodynamics. Flow in boundary layer, Prandtl theory. Heat transfer; separation.

### MA603 (7303) Theoretical Aerodynamics II.

Basic equations, fundamental theorems and normal shock waves. Linear and nonlinear small-disturbance equations. Linearized theory of two-dimensional and axisymmetric flows: three-dimensional wings; supersonic area-rule. Exact theories; oblique shock waves and shock wave interactions; method of characteristics; conical flows; hodograph transformation. Improvements in linearized theory; thickness and Mach number expansions; second-order supersonic flow; sonic boom theory; shock wave interactions. Transonic flow; fundamental equation and similitudes; transonic area-rule; nozzle flows; airfoil design.

### MA611 (7101 and 3667) Physics of Fluids I.

Fundamental treatment of fluid properties, primarily from microscopic viewpoint, providing understanding necessary for advance study of combustion, air pollution, gas dynamics, related areas. Topics: kinetic theory of gases; BGK model equation, transport

coefficients, mean free path, conservatio equations. Chemical kinetics and chemical thermodynamics. Statistical mechanics of noninteracting particles: Fermi-Dirac, Bose-Einstein, and Maxwell-Boltzmann statistics, partition functions, specific heat of gases. Quantum mechanics: atomic structure, rotational and vibrational energy levels. At the level of Vincenti and Kruger, *Introduction to Physical Gas Dynamics* and Clarke and McChesney, *The Dynamics of Real Gases*.

### MA612 Physics of Fluids II.

Molecular structure: bonding theory, heats of reaction. Atomic and molecular spectroscopy; applications to pollution. Nonequilibrium statistical mechanics: Boltzmann equation, H-theorem, review of Hilbert-Enskog-Chapman theory, fluctuations, Onsager's relations. Radiative transfer; lasers. At the level of Clarke and McChesney, *The Dynamics of Real Gases*, and Kittel, *Elementary Statistical Physics*.

### MA613 (7102) Gasdynamics.

Strong shock waves and their use in production and study of high-temperature gases. High-temperature chemical kinetics and its application to hypersonic external flows, rocket internal flows, other phenomena of current interest. Chemical relaxation effects of flow fields and method of characteristics including chemical reactions. Experimental techniques.

### MA621 (7201) Introductory Plasma Physics.

Intended to be a first course in plasma physics and includes: plasma state, particle orbits in electric and magnetic fields, adiabatic invariants, Coulomb scattering, transport phenomena, plasma oscillations and waves, hydromagnetic equations, energy principle and instabilities, applications to laboratory and space plasmas, introduction to controlled thermonuclear research. At the level of *Elementary Plasma Physics* by Longmire.

### MA622 (7202) Introductory

**Magnetohydrodynamics.** Basic equations of magnetohydrodynamics. Flow problems. Hydromagnetic shock waves. The pinch effect and instabilities. Tensor conductivity and excess electron temperature.

### MA671 (3671) Aerospace Propulsion Systems.

Application of thermodynamics and fluid mechanics to design and performance of thermal-jet and rocket engines in atmosphere and in space. Mission analysis in space as it affects propulsion system. Consideration of auxiliary power supply; study of advanced methods of space propulsion.

### MA704 (7304) Theory of Viscous Flows.

Systematic study of laminar flow phenomena and their methods of analysis: vorticity diffusion and flow development. Linear and nonlinear exact solutions of

Navier-Stokes equations. Linearized theory: viscous acoustics, and small Reynolds number approximation. Matched asymptotic expansion. Boundary layer equation and its general properties. Singular solution and separation point. Transformations for compressibility and axisymmetric effects. Similar solutions; approximate methods of calculation. Three-dimensional and unsteady problems. Stability of laminar flows.

**MA705 (7305) Hypersonic Flow Theory.**

Hypersonic small disturbance theory and related similitude; blast wave analogy; entropy layers. Newtonian theory and shock layer structure. Constant density solutions. Blunt body problem; numerical techniques. Viscous and real gas effects; ideal dissociating gas; viscous interactions; other real gas phenomena.

**MA706 (7306) Atmospheric Motions.** Emphasis on mathematical and physical understanding of synoptic scale motions. Atmosphere; basic scales of synoptic motions; thermodynamics. Equations of motion; rotating and spherical coordinates. Geostrophic flow; Rossby number; hydrostatic approximation; isobaric coordinates; balanced motions; thermal wind; prognostic equations. Circulation and vorticity; Ertel's theorem and potential vorticity. Planetary boundary layer; Reynolds' stress, Ekman layer. Diagnostic equations; baroclinic motions. Sound, gravity, and Rossby waves. Analytical and numerical models; filtered equations; baroclinic model; primitive equations. Cyclogenesis; fronts and frontogenesis. General circulation; energy and momentum; numerical simulation.

**MA707 (7307) Aerodynamic Noise Theory.**

Advanced topics in acoustics relevant to aerodynamic and transportation noise sources and control. Measurements and annoyance scales. Random processes. Geometrical acoustics in inhomogeneous moving media. Kirchhoff and Poisson formulas, diffraction, scattering. Lighthill-Curle formulations for sound generation. Moving sources. Jet, rotor, and boundary layer noise. Absorption and transmission in fluid and at boundaries.

**MA713 (7103) Dynamics of Rarefied Gases.** Flow regimes according to the Knudsen number. Theories of shock structure at high Mach numbers. Boundary conditions at a solid wall. Slip-flow conditions. Free-molecule flows. Eigen function expansion of the linearized Boltzmann equation. Full-range and half-range moment methods. Model equation approach and recent developments for handling transition regime.

**MA723 (7203) Intermediate Plasma Physics.**

Collective oscillations in a cold plasma; waves in a warm plasma; application to natural phenomena. Nonlinear theory of collision-free shocks. Quantum effects in solid state plasma waves; plasma-phonon interactions. Introduction to radiation and scattering in plasmas. At the level of *Theory of Plasma Waves* by Stix; and *Radiation Processes in Plasmas* by Bekefi.

**MA792 (7902) Seminar in Aerospace Engineering.**

Study and discussion of topics of current research interest in aerospace engineering. Members of seminar prepare and deliver reports on these topics, based on published literature.

**MA793 (7903) Plasma Physics Colloquium.**

Lectures by staff members, graduate students, visiting scientists on topics of current interest in plasma research.

**MA795 Special Topics in Aerospace Engineering.**

Topics of current importance in aerospace engineering and research. Lecture or seminar format. More than one topic may be taken if offered.

**MG791 Mechanical and Aerospace Engineering Research Conference.**

Short presentations on research in progress by students and staff.

**MG799 Mechanical and Aerospace Engineering Colloquium.**

Lectures by Cornell staff members, graduate students, and visiting scientists on topics of interest in aerospace science and mechanical engineering, especially in connection with new research.

**MG890 and MG990 Research in Mechanical and Aerospace Engineering.**

Independent research in an area of mechanical and aerospace engineering under guidance of member of staff.

## African and Afro-American Studies

### African Heritage

**470 Nineteenth Century Resistance Movements.**

Detailed examination of development of black resistance movements in Africa and America; study of how these movements were related. Investigation of personalities involved and their impact on their time.

**475 Men and Movements in the Black Urban Ghetto.**

Seminar intended to examine twentieth-century personalities and political, social, and religious movements that have influenced black ghettos in the U.S.

**483 Themes in African History.**

Designed to expose the student to what has been referred to as "particular aspects" of African history. In any given term, a specific theme examined in regard to its significance in the historical process in Africa. Use made where necessary of work done in auxiliary disciplines. Reveals main lines of African development and examines how these have been interpreted.

**490 An Advanced Reading and Research Seminar in Black History.**

Designed to help students acquaint themselves with available sources of information and materials in black history, and to make maximum use of inclinations and interests in unearthing material and creating a body of

comprehensible conclusions and generalizations from it.

**505 Workshop in Teaching about Africa.** Enables students to gain experience in handling of various problems involved in teaching about Africa. Special attention paid to evaluation of materials on Africa, correction of myths and misconceptions about Africa, application of current methods of education to task of teaching about Africa, and analysis of problems in African historical texts.

**510 African Heritage: Historiography and Sources.** In-depth examination of problems encountered by historians in attempting to reconstruct African past. Emphasis on perspectives and how these affect conclusions.

**515 Comparative Political History of the African Diaspora.** Designed as comparative study of selected African nations to trace their political evolution and its effect on African diaspora. Examination of contrasts in political development of nations selected for study.

**520 African Heritage: Historical Method, Sources, and Interpretation (Independent Research Seminar).** Emphasis on methods and problems involved in reconstruction of African history. In-depth examination of oral tradition as a source of history; techniques devised for testing and authenticating.

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

### **African Politics and the Sociopolitical Study of Black People in America**

**420 Politics and Black Community Organization.** Examination of social, political, economic factors contributing to development and perpetuation of ghettos, principally in urban areas. Particular emphasis on current conditions in black communities.

**484 Liberation Movements.** Investigation of theory of revolution in Africa: its ideology, interrelationships, and tactics. An attempt to plot some dynamic pattern by tracing history of liberation movement in subequatorial Africa as accent shifts from nonviolence to armed struggle.

**485 Racism, Social Structure, and Social Analysis Seminar.** Systematic discussion and study of interrelated process of racism to social structure in America, and its consequence for social analysis of function and prevalence of racism in society.

**500 Political Ideology, Planning, and Development in Africa.** Discussion of problems of economic development and political modernization in Africa, and examination of the various ideologies which have worked out in response to problems. Particular attention given to role of planning in economic development prescribed by various

ideologies and relationship of planning to political system as a whole.

**551 Political History of Social Development in the Caribbean.** Investigation of history of British Caribbean, with a view to analyzing strategies and tactics employed by slaves and their succeeding generations in order to come to terms with new environment.

**566 Politics and National Integration in Africa.**

**571 Infancy, Family, and the Community.**

### **Afro-Literature and Black Expression**

**422 African Literature.** Study of basic themes in twentieth-century literature produced by Africans south of Sahara. Selected works examined, including literary techniques employed by writers.

**425 Advanced Seminar in Black Theatre.** Study of total black theatre as revealed in music and art. Criticism of black dramatic literature. Delineation of problems, approaches, and philosophies of black acting, direction, writing, theatre production.

**465 Black Critique: Towards Defining and Developing a Black Aesthetic.** Examination of need for developing a black critique by positioning a system of aesthetic, moral, and cultural values in terms of which judgments can be made. Topics explored: aesthetics vs. ethics; nature of blackness and black artist; language, form, and content; blackness and universality; form in relation to content, theme, message, etc.

**480 Black American Writing and Politics.** A seminar dealing with basic areas of American race relations by examining what black men and women have thought and dreamed as expressed in what they wrote. Focuses on cultural position of blacks in United States society at different periods in last 170 years.

**498-499 Independent Study.** For students working on special topics with selected readings, research projects, etc., under supervision of a member of faculty of Africana Studies and Research Center.

**Anthropology 438 Ethnology in Africa.**

**Anthropology 520 Ethnolinguistics.**

**Anthropology 539 Africa.**

**Economics 671-672 Economics of Development.**

**Education 476 The Urban School.**

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

**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.**

Emphasis on evaluating profitability of alternative investments and enterprises. Principal topics: linear programming, capital budgeting, influence of change on farm organization, financial risk and uncertainty. Experience in computer applications to farm business management provided.

**405 Farm Finance.** Study of sound financial arrangements for farmers and credit institutions which serve them. Emphasis on problems of capital management associated with organizing and operating a commercial farm. Alternative sources of capital analyzed; consideration of safe and profitable debt levels and selection of alternative investment opportunities. Tax management, insurance programs, retirement and estate planning for farmers.

**406 Farm Appraisal.** Study of factors governing price of farms, methods of farm valuation, practice in appraisal of farms and other rural properties.

**412 Introduction to Quantitative Methods.**

Introduction to decision making under uncertainty, decision rules, inventory control, game theory, linear programming, special linear programming problems.

**424 Managerial Decision Making.** An intergrating course which examines business policy formulation and execution from standpoint of corporate manager. An advanced course for potential business managers and/or owners. Topics: concepts and function of strategy, nature of a company's environment, interdependence of formulation and implementation of strategy, role of leadership in achieving business goals.

**425 Personal Financial Management.** Discussion sessions devoted to problems and case studies in financial planning for students and young families. Discussion leaders include representatives of financial institutions including banks and insurance companies.

**441 Food Distribution.** Study of structure and competitive nature of food industry. An analysis of gross margin, expenses, earnings, performance of food retailers. Government regulations with regard to mergers and buying and selling activities examined. Leading food industry authorities frequently join discussion session.

**443 Food Industry Management.** Case study approach used to examine application of management principles and concepts to operating problems of food retailers. Areas include site

selection, buying, merchandising, personnel administration, private label products, financing expansion programs. Leading food industry specialists frequently join discussion session on Wednesday afternoons.

**449 Field Study of Marketing Institutions.**

Economic functions performed by various types of specialized marketing agencies with emphasis on their physical operating patterns. Observations made of organization and operation of businesses in food industry. Five days of spring vacation spent in Boston visiting food distribution firms and marketing institutions.

**450 Resource Economics.** Review of application of economic and political science concepts to problems in use of natural resources including, but not restricted to, water, land, forests, fisheries, with emphasis on public management of environment. Attention given to concepts of regional growth, impact of urban growth, public decision making in resources area.

**452 Studies in Regional Agricultural Development.**

Practical procedures for appraising agricultural development potentials and generating suggestions for agricultural development programs in regions smaller than nations. Physical, biological, economic, social, and political aspects examined from point of view intermediate between the micro and macro levels traditionally recognized in economics. Examples drawn from U.S. and foreign areas. Laboratory and field trips provide opportunities for practice and observation.

**464 Economics of Agricultural Development.**

Examination of processes of economic development in developing nations, and their interactions with U.S. policy. Rural development policy receives primary attention with emphasis on developing nations with a dominant agriculture sector, on key role of agriculture in overall economic transformation of these economies and on interactions of U.S. agricultural policy as a major component of total U.S. policy with respect to developing nations.

**608 (508) Production Economics.** Comprehensive survey of production economic theory with emphasis on applications to agriculture and agribusiness. Topics: derivation and use of production, cost, supply functions.

**637 Administration of Public Agricultural Programs.**

Examination of government organizations for administering and financing public agricultural programs; study of some problems of administration and finance, including organization of agencies, management of personnel, budgetary management, interagency relationships (national, state, local), relationships among national, state, local levels of government.

**641 (541) Food Merchandising.** Seminar exploring alternative merchandising and promotional devices for food industry retailers and manufacturers. Identification and measurement of basic forces having an impact on consumer buying behavior.

**650 (550) Economic Analysis of Public**

**Investment.** Application of economic theory and analysis to governmental budgeting and expenditures process with emphasis on the welfare criteria of economic efficiency and income distribution.

Techniques of benefit-cost analysis, equity analysis, systems analysis, planning-programming-budgeting systems. Discount rates, benefit estimation, externalities, multipliers, risk and uncertainty, social welfare functions. Also, issues of cost sharing and reimbursement, the way and means of intergovernmental payments.

**652 (552) Special Problems in Land Economics.**

Special work on any subject in the field of land economics that is of particular interest to student.

**660 (560) Food, Population, and Employment.**

Introduces students in social and biological sciences to relationships linking employment, food, population growth in developing countries. Food economics: human food requirements, major food groups and their economic characteristics (including historical trends in food consumption), techniques of national food accounting (including data collection and evaluation), projection of demand, disaggregation of data for analysis of particular problem groups and areas (notably burgeoning number of urban dwellers and peasants bypassed by technological change). Historical relationships between food and population: employment, income generation, effective demand. Ample opportunity afforded to work with SAMI and other vital-rate monitoring devices. Term paper expected.

**665 Seminar on Latin American Agricultural**

**Policy.** Examination of Policies for development of agricultural sector in Latin America; including identification of policy objectives and review of instruments of public policy implementation. Particular attention paid to contribution of research studies in agricultural policy formation and accomplishment.

**710 (510) Econometrics I.** Comprehensive treatment of classical regression model with selected extensions, including an introduction to simultaneous equations models and estimation methods about at the level of *Econometric Methods* by J. Johnston. Emphasis on correct applications of econometric tools with most examples drawn from microeconomic problems in agriculture.

**711 (511) Econometrics II.** Extension of multiple regression analysis to include generalized least squares, analysis of covariance models, stochastic parameter models. Applications emphasize microeconomic problems using single equation techniques: distributed lag models in investment theory. Additional topics: principal components, factor analysis, profit analysis.

**712 (512) Quantitative Methods I.** Linear programming with extensions, including postoptimality analysis, transportation and assignment models, risk programming, game theory,

input-output models. Applications made to problems in agricultural, resource, regional economics.

**713 (513) Quantitative Methods II.** Probabilistic models and methods including queuing theory, inventory theory, Markov chains, dynamic programming, simulation. Applications to a variety of problems in agricultural economics and business management used to explore and evaluate techniques.

**714 (610) Econometric Models.** Theoretical and practical aspects of specifying and evaluating econometric models. Selected empirical studies in agricultural economics serve as basis for discussion. Provides depth and experience in model construction beyond that of Courses 510 and 511.

**717 (507) Introduction to Research in Agricultural Economics.** Discussion of research process, scientific method and its application in agricultural economics. Perspective provided by reviewing a variety of recent publications summarizing research efforts in this field. Topics: inductive and deductive methods, development of hypotheses, methods of testing alternatives, sources and methods of obtaining data, sampling and analytical procedures. Survey procedure and questionnaire construction reviewed.

**726 (626) Seminar in Agricultural Cooperation.**

Discussion of the economic theory and function of farmer cooperatives. Place and contribution of cooperatives in developing and developed economies; problems of structure, finance, management, control.

**740 (540) Marketing Research.** Objectives of marketing research, organization and management of research agencies, problem identification, selecting and planning projects. Designing and use of research in management of marketing function.

**741 (641) Marketing Economics.** Seminar on marketing economics with special reference to agriculture. Discussions cover: strategic role of marketing in total economic system; interdependent nature of economic activity in space, time, form dimensions; measurement and evaluation of efficiency of pricing and marketing systems, determination of efficient organizations of assembly, processing, storage, distribution in a firm and in an industry. Class, as a research team, studies and develops a solution to a marketing problem of an agricultural firm in New York State.

**742 (642) Social Responsibility in Marketing.**

Seminar course concerned with public policy in marketing. Concepts from industrial organization, consumer economics; antitrust integrated in appraising public decisions in marketing area. Examples drawn primarily from analysis of food marketing system.

**750 (650) Workshop in Resource Economics.**

Application of economic theory and analysis to governmental decision making with emphasis on graduate students' research.

**751 (651) Seminar on Agricultural Policy.**

Discussion of agricultural trade, price, and income-support policies and techniques appropriate to analysis of policy issues.

**752 (652) Readings in Philosophy.** Readings, selected for their relevance to research in agricultural economics, chosen from among books such as *Structure of Scientific Revolutions*, *The Theory of Experimental Inference*, *The Nerves of Government*, *The Structure of Economic Science*, *Economic Philosophy*, and *Probability Statistics and Truth*.

**769 (669) Seminar in Agriculture and Economic Planning Models.** Planning models as applied to less developed economies; emphasis on interaction between agricultural and nonagricultural sectors. Discussion of one sector models of Harrod-Domar type; labor surplus models such as Lewis, Fei-Ranis, Jorgensen models; multisectoral models of linear programming type. Examination of models in light of various questions related to planning such as balanced vs. unbalanced growth, choice of techniques, foreign trade, etc.

## Agricultural Engineering

**OAE415 Physical Analysis of Plant and Animal Materials.** Study and analysis of physical properties of plant and animal materials. Definition of pertinent physical properties and development of meaning of a physical property. Morphology of plant and animal materials related to problems of defining physical properties. Material product geometry examined and influence of forces on behavior of materials studied. Physical properties of plant and animal materials related to material and manipulative forces applied in growth, harvesting, processing, handling. Deformation and flow of these materials modeled. Interpretation of physical properties of plant and animal materials used in defining texture of food materials and mechanical damage to plant products.

**OAE416 Laboratory Practice in Physical Analysis.** Laboratory component of course OAE415. Course OAE416 may be taken without OAE415 by permission of instructor. Laboratory practice in physical analysis of plant and animal materials.

**OAE450 Introduction to Analog Computation.** Fundamentals of analog computing with elementary examples of applications from biological and physical systems. Basic computing elements, analog programming, scaling, computer operation. Attempt made to permit students to work on a problem related to their own area of interest. Basic knowledge of differential equations required.

**OAE461 Agricultural Machinery Design.** Principles of design and development of agricultural machines to meet functional requirements. Emphasis on computer-aided analysis and design, stress analysis, selection of construction materials, testing procedures involved in agricultural machine development. Also engineering creativity and agricultural machine systems.

**OAE462 Agricultural Power.** Utilization of internal combustion engine energy and other forms of energy in agriculture. Basic theory, analysis, testing of internal combustion engines for use in farm tractors and other agricultural power applications. Specific study of tractor transmissions, Nebraska Tractor Tests, soil mechanics related to traction and vehicle mobility. Economic and human factors in power use and application.

**OAE465 Processing and Handling Systems for Agricultural Materials.** Processes such as size reduction, separation, metering, drying studied. Psychrometrics, fluid flow measurement, an introduction to dimensional analysis and controls for agricultural applications. Problem solutions employ both the analog and digital computers. The student should know how to utilize computers prior to enrollment.

**OAE471 Soil and Water Engineering.** Emphasis on integrated planning, design, operation of systems for solution of soil and water problems. Interactions of economic, social, political factors with engineering design stressed. Major problem area emphasis is on deficit water conditions, though excess water problems considered.

**OAE475 Systems Models for Environmental Quality Control.** Introduction to use of systems analysis techniques in study of environmental quality problems. Emphasis on role of mathematical modeling as a technique for identifying alternative means of satisfying environmental quality objectives. Techniques of simulation and linear and dynamic programming applied to such areas as water quality control, solid waste management, pest control, air pollution control, agricultural wastes. Students encouraged to select course projects from their fields of interest.

**OAE481 Agricultural Structures Design.** Application of basic structural concepts to design of agricultural structures. Emphasis on wood structures including design of trusses, rigid frames, prefabricated panels, columns. Design of reinforced concrete members and steel members. Economic considerations also presented.

**OAE482 Environmental Control for Animals and Plants.** Study of thermal interchanges with the environment between animals (including man) and plants. Understanding of physiological principles affecting thermal comfort and health. Ventilation, air conditioning, psychrometrics, insulation, condensation control, solar energy, weather phenomena.

**OAE491 Highway Engineering (Civil Engineering IID632 (2432)).** Study of economic considerations in road system improvement, road improvement planning and programming, road location and geometric design, traffic engineering soil characteristics and classification, drainage, stabilization methods and materials, wearing surfaces, design of roadbed thickness. Emphasis on secondary roads.

**OAE492 Bituminous Materials and Pavement Design.** Properties of asphalts, aggregates, and bituminous mixtures; bituminous mixture design; pavement construction. Seal coat and surface treatment design and construction. Pavement maintenance. Flexible pavement design methods; rigid pavement design methods.

**OAE501-502 Master of Professional Studies (Agriculture) Project.** Comprehensive project utilizing applied problems pertinent to agricultural engineering. Required of each Master of Professional Studies (Agriculture) degree candidate in the Field.

**OAE551-552 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 best alternative.

**OAE651 Similitude Methodology.** Similitude methodology, including use of dimensional analysis to develop general equations to define physical phenomena, model theory, distorted models, analogies, with introduction to a variety of applications in engineering. Problem solutions employ both analog and digital computers. It is preferred that the student know how to write programs to utilize digital computer prior to enrollment.

**OAE652 Instrumentation.** Emphasis on 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, flow; data acquisition systems, including telemetry.

**OAE675 Solid Waste Management (Civil Engineering IIE630 [2530]).** Study of municipal, industrial, agricultural solid wastes. Emphasis on waste characteristics, methods of treatment and disposal, interrelationships with the air, water, land environment. Discussion of economic and political aspects. Enrollment also open to nonengineering students.

**OAE676 Industrial Waste Management (Civil Engineering IIE631 [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, case studies. Emphasis on liquid industrial wastes.

**OAE678 Environmental Quality Management for AgroEcosystems (Civil Engineering IIF751 [2651]).** Application of systems analysis and mathematical ecology to problems in ecosystem management and environmental quality. Topics: pest control, fertilizer usage, eutrophication, agricultural waste, soil and

water conservation, public policy decisions affecting ecosystem management.

**OAE685 Biological Engineering Analysis.** Engineering problem-solving strategies and techniques explored. Students solve several representative engineering problems which inherently involve biological properties. Mathematical modeling emphasizes problem formulation and interpretation of results. Student's knowledge of fundamental principles extensively utilized. Principles of feedback control theory applied to biological systems.

**OAE700 Agricultural Engineering Seminar.** Presentation and discussion of research and special developments in agricultural engineering and other fields.

**OAE750 Orientation for Research.** Introduction of newly joining graduate students to departmental research policy, programs, methodology, resources, candidate responsibilities and opportunities.

**OAE761 Power and Machinery Seminar.** Study and discussion of research and new developments in agricultural power and machinery.

**OAE771 Soils and Water Engineering Seminar.** Study and discussion of research on selected topics in irrigation, drainage, erosion control, agricultural hydrology.

**OAE775 Agricultural Waste Management Seminar.** Study and discussion of the management of agricultural wastes with emphasis on physical, chemical, biological, economic, aesthetic considerations.

**OAE781 Agricultural Structures Seminar.** Study and discussion of farmstead production problems with emphasis on biological, economic, environmental, structural requirements.

**OAE785 Biological Engineering Seminar.** Interaction between engineering and biology examined, especially environmental aspects of plant, animal, human physiology, in order to improve communications between engineers and biologists.

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

## Agronomy

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

**403 Soil Organic Matter and Organic Soils.**

**404 Forest Soils.**

**405 Soil Clay Mineralogy.**

**407 Soil Physics, Lectures.**

**410 Microbial Ecology.**

**422 Tropical Agriculture.**

- 450 **Special Topics in Soil Science.**
- 480 **Management Systems for Tropical Soils.**
- 481 **Special Studies in Soils of the Tropics.**
- 506 **Use of Soil Information and Maps as Resource Inventories.**
- 522 **Special Studies in Tropical Agriculture.** May include field laboratory trip to tropical area during January intersession.
- 602 **Chemical Methods of Soil Analysis.**
- 603 **Morphology, Genesis, and Classification of Soils.**
- 606 **Advanced Soil Microbiology.**
- 607 **Soil Physics, Lectures.**
- 608 **Soil Physics, Laboratory.**
- 613 **Crop Ecology.**
- 614 **Grasslands and Grassland Research.**
- 650 **Research Orientation and Perspective.**
- 651 **Special Topics in Field Crop Science.**
- 661 **Research in Field Crop Production.**
- 701 **Soil Chemistry.**
- 724 **Soil Fertility, Advanced Course.**
- 760 **Research in Soil Science.**
- 790 **Agronomy Seminar.** Required of graduate students majoring or minoring in the Field.
- 791 **Soil Science Seminar.** Required of students whose major or minor subject is soil science.
- 792 **Crop Science Seminar.** Required of students whose major or minor subject is crop science.

### Atmospheric Science

The following courses carry Atmospheric Science numbers.

- 411 **Basic Theoretical Meteorology I.**
- 412 **Basic Theoretical Meteorology II.**
- 417 **Physical Meteorology.**
- 438 **Atmospheric Pollution.**
- 449 **Physics of Clouds, Rain, and Rainmaking.**
- 650 **Special Topics in Meteorology and Climatology.**
- 691 **Seminar in Meteorology.**
- 962 **Research 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.**

### Animal Science

**400 Livestock Production in Warm Climates.** Factors inhibiting efficient livestock production and some of the potential roles animals can fulfill as sources of food, power, fiber in tropical areas of 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 made on some problems influencing livestock in tropics.

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

**410 Principles of Animal Nutrition.**

**411 Principles of Animal Nutrition, Laboratory.**

**420 Quantitative Animal Genetics.** Consideration of problems involved in improvement of animals, especially farm animals, through the application of theory of quantitative genetics with emphasis on 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.** Introduction to methods of research in quantitative genetics and animal breeding including estimation of heritability, repeatability, 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, quantitative characters; progeny testing, genetic relationships and inbreeding. For veterinary students only.

**427 Fundamentals of Endocrinology.** Physiology of endocrine glands and roles played by each hormone in regulation of normal body processes.

**430 Livestock Improvement through Artificial Breeding.**

**451 Physiology and Biochemistry of Lactation.**

Advanced course in anatomy of mammary gland, physiological mechanisms of milk secretion, biochemical synthesis of milk constituents in laboratory and farm animals.

**490 Science and Technology of Meat and Eggs.**

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. Basic principles of meat preservation, processing, meat product development through laboratory demonstration and practice in 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 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.** Causes and phenotypic effects of chromosomal aberrations in higher animals, as these affect embryo development, postnatal growth, behavior. Attention given to genetic, physiological, environmental variables that may cause meiotic and mitotic abnormalities. Demonstrations include cytogenetic, cytochemical, cytophotometric techniques.

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

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

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

**450 Poultry Meat and Egg Technology.**

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

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

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

**Anthropology**

**412 Contemporary Anthropological Theory.**

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

**414 Anthropology and History.**

**415 Classic Ethnography.**

**418 Ethnohistory.**

**421 Comparative Social Systems.**

**424 Myth, Ritual, and Symbol.**

**451 Archaeological Boundaries: Arts.**

**452 Archaeological Boundaries: Sciences.**

**453-454 Projects in Art, Science, and Archaeology.**

**456 Meso-American Thought and Culture.**

**471-472 Laboratory Methods in Biological Anthropology.**

**493 Seminar in Archaeology.**

**497-498 Topics in Anthropology.**

**602 The Design of Field Research.**

**603 Human Biology and Cultural Behavior.**

**607-608 Special Problems in Anthropology.**

**610 The Anthropological Study of Art.**

**612 History of Anthropological Thought.**

**613 Contemporary Anthropological Theory.**

**614 Applied Anthropology.**

**617 Conceptual Systems in Anthropology.**

**618 Cultural Processes: Role "Theory" and Cultural Change.**

**620 Ethnolinguistics.**

**623 Social Systems: The Anthropology of Face-to-Face Interaction.**

- 626 **Problems In Economic Anthropology.**
- 628 **Political Anthropology: Culture and Politics.**
- 630 **North America.**
- 631 **Middle America.**
- 632 **South America: Lowland Research.**
- 633 **Andean Research.**
- 634-635 **Southeast Asia: Readings in Special Problems.**
- 637 **Islamic Sects and Religious Movements.**
- 640 **South Asia.**
- 641-642 **South Asia: Readings in Special Problems.**
- 643 **China.**
- 645 **Japan.**
- 648 **Comparative Studies in Complex Societies: Agrarian Civilizations.**
- 664 **Problems In Archaeology: Europe.**
- 667 **Origins of Meso-American Civilizations.**
- 673 **Human Adaptation.**
- 675 **Physical Anthropology: History and Theory.**
- 676 **Physical Anthropology: Problems, Methods, and Theory.**
- 678 **Paleoanthropology: South Asia.**
- 698-699 **The Teaching of Anthropology.**
- 901-902 **Field Research.**
- Architecture 667-668 Architecture in its Cultural Context.**
- Asian Studies 601-602 Southeast Asia.**

## 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, Theoretical and Applied Mechanics.

## Applied Physics

The following courses carry Engineering Physics numbers.

**IPA333 (8133) Mechanics of Particles and Solid Bodies.** Primarily for majors in engineering physics. Newton's laws; coordinate transformations; generalized coordinates and momenta, Lagrangian and Hamiltonian formulation; applications to oscillator, restrained motion, central forces, small vibrations of multiparticle systems, motion of rigid body.

### **IPA355 (8155) Intermediate Electromagnetism.**

Topics: vector calculus, electrostatic and magnetostatic fields as solutions of boundary value problems, dielectric and magnetic media, mechanical and electric energy and pressure. Also, electric induction phenomena, skin effect, and introduction of displacement current. Emphasis on application of concepts to physical phenomena and engineering. At the level of *Lectures on Physics*, Vol. II, by Feynman, and *Foundations of Electromagnetic Theory* by Reitz and Milford.

**IPA434 (8134) Continuum Physics.** Stress tensor; equation of reaction; Euler's equation; incompressible and compressible flow; strain tensor; elements of elasticity theory; elastic waves; viscous liquids, and anelastic solids.

### **IPA456 (8156) Intermediate Electrodynamics.**

Development of electromagnetic wave phenomena and radiation. Topics: transmission lines, waveguides, wave properties of dispersive media, radiation and scattering phenomena, reciprocity, physical optics, and special relativity. Emphasis on concepts and their application to physical phenomena and engineering. At the level of *Lectures on Physics*, Vol. II by Feynman, and *Classical Electromagnetic Radiation* by Marion.

### **IPB612 (8512) Electron Microscopy and Diffraction.**

Discussion of selected topics in areas of electron microscopy and diffraction, with major emphasis on microscopy. Probable topics: elastic and inelastic electron scattering from atoms, molecules, aggregates of matter; nature of image formation—amplitude, phase, diffraction contrast; resolution; magnetic domain structure as phase grating and atomic planes as diffraction grating; kinematical 2-beam, and n-beam dynamical theories of perfect crystals; phenomenological treatment of absorption; extension to imperfect crystals—diffraction contrast from defects such as dislocations, stacking faults, coherent and incoherent precipitates; discussion of inelastic scattering; instrumental and fundamental limitations on source properties and image formation capabilities and reasons for current research activities devoted to extending capabilities.

### **IPB711 (8211) Principles of Diffraction (Materials Science and Engineering ITF706).**

Broad introduction to diffraction phenomena as applied to solid-state problems. Production of neutrons and X-rays, scattering and adsorption of neutrons, electrons, X-ray beams. Diffraction from two- and three-dimensional periodic lattices. Crystal symmetry, Fourier representation of scattering centers; the effect of thermal vibrations on scattering. Phonon information from diffuse X-ray and neutron scattering; Bragg reflections. Standard crystallographic techniques for single crystals and powders. Diffraction from almost periodic structures, surface layers, gases, amorphous materials. Survey of dynamical diffraction from perfect and imperfect lattices. Techniques for imaging structural defects. At the level of *Optical Principles of the Diffraction of X-Rays* by R. W. James, *X-Ray Diffraction* by B. E.

Warren, *Electron Diffraction* by Vainshtein, and *Electron Microscopy of Thin Crystals* by Hirsch, et al. Lectures accompanied by experiments on fluorescence and polarization of X-rays, diffractometer measurements of vibrational amplitudes in crystals, natural widths of emission lines, identification of crystal structures, crystal orientation by back reflection techniques.

**IPB712 (8212) Selected Topics in Diffraction (Materials Science and Engineering ITF712).**

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, vibrational amplitudes. Diffuse scattering, short- and long-range order, precipitation in solids, point defects.

**IPB762 (8262) Physics of Solid Surfaces (Materials Science and Engineering ITG762).**

Introduction to recent theoretical and experimental advances in physics and chemistry relating primarily to electronic, atomic, molecular properties of solid surfaces. Fundamental approaches to understanding of surface phenomena in terms of underlying microscopic and atomistic principles of physics and chemistry emphasized. Surface properties associated with electron structure, electron and mass transport, chemical bonding, lattice imperfections, surface reactions and transformations, atomic structure and composition compared. Impact of major recent advances in both experimental high vacuum physics and in theoretical description of electron structure relative to emission, scattering, transport, and chemical reactions at surfaces considered. Relevancy of new physical and chemical understanding of solid surfaces to applications in science and engineering included where pertinent. Presented at the level of *Molecular Processes on Solid Surfaces* edited by E. Drauglis, R.D. Gretz, and R.I. Jaffee.

**IPC201 (8301) Nuclear Energy and the Environment.**

Fundamentals of nuclear radiations and their measurement and interaction with matter, the natural radiation environment, sources of man-made radioactivity (five weeks); radiation chemistry, radiation biology, somatic and genetic effects of nuclear radiation, movement of radioactive materials in biosphere, bases of radiation protection standards (five weeks); environmental effects of nuclear electricity generation and nuclear fuel mining, processing, waste storage, control of radiation hazards, waste heat problems (four weeks).

**IPC303 (8303) Introduction to Nuclear Science and Engineering.**

Introductory course in low-energy nuclear physics and nuclear engineering. Acquaints students with low-energy nuclear physics and some of its practical applications. Topics: elementary quantum mechanics; properties and structure of nuclei; radiations emitted by nuclei and their interaction with matter; nuclear reactions, with emphasis on fission and fusion processes; neutron chain reaction; types and uses of nuclear radiations,

e.g., neutron activation analysis and radioactive tracer analysis.

**IPC609 (8309) Low-Energy Nuclear Physics.**

Nuclear interaction. Properties of ground and excited states of nuclei; models of nuclear structure; alpha, beta, gamma radioactivity; low-energy nuclear reactions — resonant and nonresonant scattering, absorption, fission. At the level of *Introduction to Nuclear Physics* by Engle.

**IPC610 (8310) Nuclear Structure Physics.** Topics: symmetry properties of nuclei, collective model, basic reaction theory, compound and direct reactions, optical model, charged particle reactions. At the level of *Physics of the Nucleus* by Preston.

**IPC612 (8312) Nuclear Reactor Theory I.** A first course in the physical theory of fission reactors. Fission process and essential properties of neutron interactions with matter described. Theory of neutron diffusion, slowing down, thermalization is developed. Theory applied to calculations of criticality and neutron flux distribution in nuclear reactors. Attention restricted to idealized configurations in order to illustrate physical ideas involved. Nuclear reactor kinetics and neutron transport theory introduced. At the level of *Nuclear Reactor Theory* by Lamarsh.

**IPC613 (8313) Nuclear Reactor Theory II.**

Continuation of IPC612, primarily intended for students planning research in nuclear reactor physics and engineering. Boltzmann linear transport equation, its adjoint, approximate solutions developed and applied to heterogeneous neutron chain reactor. Theories of fast fission effect, resonance escape, thermal utilization developed for heterogeneous reactors. Escape probability formulation of reactor lattices, neutron importance function, perturbation theory, temperature coefficients of reactivity, fission product poisoning. At the level of *The Physical Theory of Neutron Chain Reactors* by Weinberg and Wigner.

**IPC633 (8333) Nuclear Reactor Engineering.**

Selected set of topics representing 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, nuclear fuel cycles. At the level of *Nuclear Reactor Engineering* by Glasstone and Sesonske.

**IPC634 (8334) Nuclear Engineering Design Seminar.**

Group design study of a selected nuclear reactor system. Emphasis on safety, siting, and radiation protection in design of nuclear power systems.

**IPC636 (8336) Seminar on Thermonuclear Fusion Reactors.**

Present state of technological and engineering problems expected in design and construction of thermonuclear fusion reactors analyzed. Topics: basic reactor containment schemes, materials development, mechanical and heat transfer problems, refueling, radiation and safety

hazards, superconducting magnets, energy conversion, economics.

**IPC651 (8351) Nuclear Measurements Laboratory.**

Laboratory experiments plus lectures on interaction of radiation with matter and on radiation detection, including electronic circuits. Twenty different experiments available in 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, properties of a subcritical assembly. Many experiments use TRIGA Reactor. Students expected to perform eight to ten experiments, selected to meet their needs. Some stress placed on independent work by students.

**IPC652 (8352) Advanced Nuclear and Reactor Laboratory.**

Laboratory experiments and experimental methods in nuclear physics and reactor physics. Ten different experiments available, among them ones using Zero Power Reactor critical facility. Offered on independent study basis or, if sufficient demand, as formal course.

**IPD401 (8501) Physics of Atomic and Molecular Processes.**

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

**IPD609 (8509) Molecular Energy Transfer.**

Fundamentals of energy transfer by molecular collisions in gases. Energy transfer mechanisms in molecular and chemical lasers. Intermolecular potential, dispersion forces, multipole moment interactions, repulsive forces. Processes for interconversion of vibration, rotation, translational energy. Perturbation methods in vibrational energy transfer. Survey of experimental data and techniques for measurement of rates of energy transfer: shock tubes, laser-induced fluorescence, laser schlieren, optic acoustic effect. Transfer chemical lasers, vibration-vibration pumping, dissociation lasers. Laser diagnostics of chemically reacting systems.

**IPE606 (8506) Introduction to Plasma Physics (Electrical Engineering IEE681).**

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.

**IPE607 (8507) Advanced Plasma Physics**

**(Electrical Engineering IEE682).** 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.

**IPF306 (8606) The Physics of Life.** Physics of life within unity and interdependence of living matter. Aimed at developing in student an appreciation for applicability of physical principles in understanding processes which underly our life. Topics: photosynthesis as elucidated by molecular spectroscopy, protein structures and reactivity as exemplified by hemoglobin (the plant-animal interface), membrane function in terms of metabolism (a parallel process to respiration), reproduction of the organism and nucleic acids, perception by organism.

**IPF601 (8601) Photosynthesis (Biological Sciences 545).** Detailed study of process by which plants use light in order to grow, emphasizing physical and physicochemical aspects of problem.

**IPF603 (8603) General Photobiology (Biological Sciences 547).** Study of major interactions between light and living matter as encountered in photosynthesis, vision, regulation of physiology and development, bioluminescence, damage by ultraviolet and visible light.

**IPF605 (8605) Optics In Biology (Biological Sciences 405).** Lectures, problems, demonstrations, laboratory experience in applications of optics to biology. Topics: geometrical optics as applied to illumination systems, methods of studying biological effects of light, analytical uses of optical absorption and fluorescence.

**IPG323 (8123) Statistical Thermodynamics.**

Quantum statistical basis for equilibrium thermodynamics, canonical and grand canonical ensembles, partition functions. 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, Maxwell-Boltzmann statistics. Introduction to systems of interacting particles. At the level of *Thermal Physics* by Kittel and *Statistical and Thermal Physics* by Reif.

**IPG424 (8124) Statistical Physics.** I. Elementary kinetic theory of gases in terms of single-particle distribution function: transport processes involved in viscosity, heat conductivity, particle diffusion, electrical resistivity. Boltzmann equation and H theorem. II. Fluctuations and irreversible processes: master equation, Langevin equation, Fokker-Planck equation, Brownian motion. Electromagnetic noise and Nyquist's theorem. Wiener-Khinchine relations. Entropy production and Onsager reciprocal relations.

**IPG461 (8161) Introductory Quantum Mechanics.**

A first course in systematic theory of quantum phenomena. Topics: wave packets and Schroedinger equation, illustrative solutions for square well, harmonic oscillators and hydrogen atom, formal structure of quantum mechanics, angular momentum, spin, exclusion principle, perturbation theory. Introduction to symmetries and to

quantization of electromagnetic field. Similar in content to Physics BPS443. Made available in spring semester to allow flexibility in scheduling. At the level of chapters 4 through 9 of *Modern Physics and Quantum Mechanics* by Anderson.

**IPG705 (8505) Topics in Statistical Physics.** Selected topics of current research interest in statistical physics.

**IPG761 (8261) Kinetic Theory (Electrical Engineering IEE781).** Designed for students wishing a firm foundation in fluid dynamics, plasma-kinetic theory, nonequilibrium statistical mechanics. Brief review of classical dynamics. Concept of ensemble and theory of Liouville equation. Prigogine and Bogoliubov analyses of BBKGY sequence. Master equation, density matrix, Wigner distribution. Derivation of fluid dynamics. Boltzmann, Krook, Fokker-Planck, Landau, Balescu-Lenard equations. Properties and theory of linear Boltzmann equation. Klimontovich formulation. Kubo theory. Coarse graining and ergodic theory. At the level of *Introduction to the Theory of Kinetic Equations* by Liboff.

**IPK217 (8117) Contemporary Topics in Applied Physics.** Selected examples of contemporary applications of modern physics. Develops a semiquantitative understanding of underlying physical principles and phenomena and intrinsic limits they place on applications. Interplay between physics and other factors (technological, scientific and, when relevant, social) which set limits on application of modern physics and influence its development: nuclear energy utilization studied in terms of physics of fission, fusion, plasmas, along with technological and social factors affecting development of nuclear energy sources. Applications of physics in other sciences such as astrophysics and biology also included.

**IPK490 (8090) Informal Study in Engineering Physics.** Laboratory or theoretical work in any branch of engineering physics under direction of member of staff.

**IPK751, 752 (8051, 8052) Project.** Informal study under direction of member of University staff. Objective is to develop self-reliance and initiative; to gain experience with methods of attack and with overall planning in carrying out of a special problem related to student's field of interest.

**IPK753 (8252) Selected Topics in Fields Technically Related to Engineering Physics.** Student expected to attend and participate in a minimum of fifteen scheduled University seminars and/or colloquia chosen in technical or scientific areas close to that of chief interest. Brief summarizing report on each of these seminars presented to staff member overseeing course. It is expected that seminar material may be augmented by student's reports by reference to and inclusion of related research reported in literature read.

## Architecture

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

**548 (488) Problems in Modern Architecture.**

**610 (139-140) Theory of Organic Architecture.** Seminar. Concepts of organic and cellular architecture, world of biological forces, concept of balance in architecture, meaning of symbols and central forms, ideas of centrum and core, morphological growth patterns and repetitions of architectural functions. Variety of concepts of habitation and planning and technical innovations discussed and researched.

**611-612 (133-134) Seminar: Urban Housing Development.** Concentrates on large-scale housing developments, particularly in relation to size, density, and problems of infrastructure.

**613 (142) Seminar: Transportation.** Impact of various transportation forms upon urban environment involving architects, engineers, planners, human ecologists. Readings and discussions including historical, current, and future transportation modes focus on aesthetic and physical aspects.

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

**618-619 (185-186) Seminar in Urban and Regional Design.**

**630-631 (309-310) Advanced Seminar in Architecture.**

**643 (473) Seminar in Medieval Art and Architecture.**

**646 (476) Seminar in Renaissance Architecture.**

**647 (477) Seminar in Baroque Architecture.**

**648 (478) Seminar in History of American Architecture.**

**649 (479) Seminar in History of Modern Architecture.**

**661 (671) Seminar in Industrialized Building.**

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

**667-668 (731-732) Architecture in Its Cultural Context.** Examination of relationship between architecture and other aspects of culture. Emphasis on motivations for particular architectural forms and

on theories of architecture formulated in "little community". Examples from Asia and U.S.

**711-712 (171-172) Problems in Architectural Design.**

**713-714 (181-182) Problems in Urban Design.**

**715-716 (191-192) Problems in Regional Design.**

**761-762 (781-782) Architectural Science Laboratory.** Projects, exercises, research in the architectural sciences.

**763-764 (791-792) Thesis or Research in Architectural Science.**

**811 (173) Thesis or Research in Architectural Design.**

**812 (183) Thesis or Research in Urban Design.**

**813 (193) Thesis or Research in Regional Design.**

**840 (491-492) Thesis in Architectural History.**

**940 (497-498) Dissertation in Architectural History.**

## Art

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

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

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

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

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

## Asian Studies

**601-602 (501-502) Southeast Asia.** Graduate-level survey of cultures and history of Southeast Asia covering pre-European, colonial, postcolonial periods, but with particular emphasis on postwar developments and contemporary problems; occasionally focuses on problem common to area as a whole, but usually deals with different country of Southeast Asia each term.

**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 astronomical information is gathered. Major unsolved

problems of modern astrophysics. Measurement of cosmic distances. Determination of masses of cosmic objects. Interaction of objects in universe. Behavior of cosmic gases in atmosphere of planets in interstellar and intergalactic medium. Formation of stars. Behavior of relativistic particles.

**432 Introduction to Astrophysics II.** Propagation of electromagnetic waves through interstellar medium; its dependence on large scale magnetic fields, and on density of matter. Origin of cosmic rays. Source of energy poured out by stars as radiation. How stars alter nuclear composition of universe as time evolves; large-scale evolutionary patterns in cosmos. Astrophysical conditions conducive to life, and how we should communicate with extraterrestrial civilizations.

**509 Theory of Gravitation.** Fundamental properties of 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 description of content and structure of universe in large. Topics treated include cosmology, relativistic stellar structure, gravitational collapse, 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, 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, dark nebulae. Planetary nebulae, novae, supernovae shells, pulsars. Galactic 21-cm emission, galactic structure, 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 origins of elements, derivation of nuclear reaction rates, stellar energy generation and synthesis processes, 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 equation of radiative transfer. Convection. Opacity sources. Limb effects. Structure of sun's visible surface. Stellar spectra and 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, interiors; roles of convective, conductive and radiative transport; optical, infrared, radio, radar, space-probe information; applications to exobiology and earth as a planet.

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

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

**579 Celestial Mechanics.** Gravitational potential of earth; two-body, three-body, restricted three-body problems; Jacobi's integral, Hill curves, libration points and stability, Lagrange's planetary equations; effects of planetary oblateness, atmospheric drag, 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, cosmic background radiation.

**640 Advanced Study and Research.** Upon sufficient demand, guided reading and seminars 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 magnetosphere and solar wind, acceleration and drift of energetic particles in magnetospheres of planets, precipitation of particles and aurora, magnetic and ionospheric storms.

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

**699 Seminar: Current Problems in Theoretical Astrophysics.** Study of latest problems in theoretical astrophysics; therefore, contents change from year to year. Students may wish to take this course more than once for credit.

## Biochemistry

All courses carry Biological Sciences numbers.

**530 Intermediate Biochemical Methods.** Intended for undergraduates majoring in biochemistry and for graduate students with minor in biochemistry. Selected experiments on carbohydrates, proteins, amino acids, metabolism (cellular particulates, kinetics, general enzymology) given to illustrate basic biochemical principles. Emphasis on the quantitative aspects rather than qualitative identification. Preregistration must be made with instructor by November 15.

**531-532 Intermediate Biochemistry, Lectures.** Appropriate for students who have previously had a one-semester introductory biochemistry course. Major areas of biochemistry covered in some detail. Fall term: proteins, enzymes and nature of enzymatic catalysis; biosynthesis of informational macromolecules. Spring term: carbohydrate, nitrogen, and lipid metabolism; bioenergetics.

**534 Biochemistry of the Vitamins and Coenzymes.** Chemical and biochemical aspects of vitamins and coenzymes. Offered in alternate years.

**535 Advanced Biochemical Methods I.** Limited to graduate students majoring in biochemistry. Instruction in use of major equipment currently employed in experimentation.

**536 Advanced Biochemical Methods II.** Limited to graduate students majoring in biochemistry. Students do research in laboratories of three different professors of their choice.

**537 Basic and Applied Science Coordination Course in Biochemistry.** Limited to graduate students in biological sciences. Series of lectures and seminars of problems of basic and applied biochemistry and its coordination.

**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 each term. May be repeated for credit. Fields covered (each field divided into three related topics): Enzyme Structure and Mechanism of Action (Fall 1974); Aspects of Protein and Nucleic Acid Synthesis (Spring 1975); Structure, Function, and Synthesis of Biological Membranes (Fall 1973, 1975); Aspects of Metabolic Pathways and Their Control (Spring 1974, 1976). Topics for the academic year 1973-74 as follows:

633 Structure of Biological Membranes.

634 Regulatory Aspects of Photosynthesis.

635 Structure and Function of Mitochondrial and Chloroplast Membranes.

636 Crystallography of Macromolecules.

637 Biogenesis of Membranes.

638 Chemistry of Nerve Transmission.

**639 Biochemistry Seminar.** Includes lectures on current research in biochemistry presented by distinguished visitors and staff.

## 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 Comparative and Developmental Morphology of the Embryophyta.**

**446 Morphology of Higher Vascular Plants.**

**448 Paleobotany.**

**463 Plant Ecology.**

**464 Evolution and Ecology of Vascular Plants.**

**543 Plant Physiology, Advanced Laboratory.**

Introduction to some modern methods in experimental plant biology.

**545 Physical Approaches to Problems of**

**Photosynthesis.** Emphasis 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 living photosynthetic tissue; contemporary investigations of the photosynthetic mechanisms. At the level of *Molecular Physics in Photosynthesis* by Clayton.

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

**548 Plant Physiology: Aspects of Metabolism.**

Selected areas of plant biochemistry reviewed in context of plant life cycle and responses to environment. Probable topics: 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 on operation of control mechanisms.

**549 Plant Physiology: Transport of Solutes and Water.** Advanced course. Transport of ions, water, 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.** Series of four topics, one presented each term, designed to provide professional background. *Families of Tropical Phanerogams.* Families of flowering plants encountered solely or chiefly in tropical regions considered. Provides basic points for recognition and understanding of diversity and relationships for students venturing into the tropics. *Literature of Taxonomic Botany.* A survey of basic reference works in taxonomy from pre-Linnaean literature drawn on by Linnaeus to contemporary publications, with comments on peculiarities of books (when appropriate), and on publication dates, typographic devices, and intricacies of bibliographic citation. *Nomenclature.* Analysis of International Code of Botanical Nomenclatures and its application to various plant groups. *Biosystematics.* Consideration of biosystematic approaches to taxonomy, including chemical, numerical, cytological, and statistical methodologies and a review of classic studies.

**649 Seminar in Systematic Botany.** Lectures and discussion led by staff, visitors, and students on topics of current importance to systematic botany.

**663 Seminar in Evolution and Ecology of Vascular Plants.** Examination of primary problems concerned with classification, evolution, 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

### Accounting

**122 Managerial Accounting.**

**300 Intermediate Accounting.**

**301 Advanced Accounting.**

**302 Cost Analysis for Management.**

**303 Seminar in Financial Policy and Accounting (Part 1).**

304 Seminar In Financial Policy and Accounting (Part 2).

305 Introduction to Taxation Affecting Business and Personal Decision Making.

306 Auditing.

307 Evaluation of Financial Statement Information.

308 Fund Accounting.

### **Business Law**

310 Law of Business Associations.

311 Advanced Business Law.

### **Finance**

128 Corporate Financial Management.

426 Short-Term Financial Management.

427 Investment Management.

428 The Public Economy.

429 The Economics of Securities Markets.

430 Money and Banking.

433 Seminar In Organized Markets.

434 Cases and Problems In Economics and Finance.

435 Seminar In Bank Management.

906 Seminar on Federal Tax Policy and Government Finance.

### **Transportation**

575 Transportation: Rates and Regulations.

576 Transportation: Structures, Operations, and Policies.

### **Managerial Economics and Economic Policy**

124A Microeconomics for Management.

124B Macroeconomics for Management.

202 Business Enterprise and Public Policy.

375 Economic and Business History.

377 Corporate Behavior and the Public Interest.

379 Economic Evaluation of Capital Investment Projects.

380 Economic Analysis and Policy.

381 Topics In United States Economic Policy.

383 Economics of Cooperative Enterprise.

384 Industry and Economic Policy.

### **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.

484 Market Segmentation.

485 Service and Public Marketing.

### **Production and Operations Management**

127 Operations Management.

525 Problems and Techniques In Production Management.

526 Case Studies In Production and Operations Management.

### **General Management**

200 Business Policy.

775 Small Business Management.

### **Hospital and Health Services Administration**

140 Introduction to Hospital and Medical Care Organization.

141 Introduction to Clinical Medicine: The Physician, The Hospital, and The Medical Care Delivery System.

142 The Social Psychology of Hospitals.

450 Evaluation of Community Health Services.

451 Psychiatric Institutions: Administration and Practice.

452 Sociopolitical Aspects of Community Health Services and Planning.

453 Legal Aspects of Hospital Administration.

454 Policy and Planning for Health Care.

455 Seminar In Health Research.

457 Health Economics.

458 Health and Welfare Policy: Foundations and Strategies for Analysis.

459 The Political Economy of Medical Care Services.

460 Quantitative Models In the Health Field.

461 The Financial Management of Hospitals.

462 Seminar In Hospital and Health Services Administration.

464 Field Studies In Health Administration and Research.

465 Seminar in Comprehensive Health Planning.

### **International Business, Development, and Economics**

624 The International Monetary System.

625 International Business Policy.

627 American Business Operations Abroad.

629 Administration of Public Operations Abroad.

631 Seminar in Political Development and Social Change.

632 Seminar on Development Administration.

636 Special Topics in International Finance.

638 Tutorial in Export Promotion.

639 Science, Technology, and Development.

640 Science, Technology, and International Relations.

### **Organizational Behavior and Personnel**

120 Organization Theory and Behavior.

121 Personnel Administration and Human Relations.

500 Processes and Techniques in Organizational Development.

502 Organizational Behavior and Administration.

503 Business and Industrial Personnel.

900 The Design of Organizations.

901 The Role of the Individual in Technological Society.

902 Seminar in Organization Theory.

904 Corporate Organization and American Society.

907 Special Topics in Organizational Theory and Behavior.

### **Public Policy and Public Administration**

129 Institutions and Values in Contemporary Society.

130 The Conduct of Public Affairs I.

131 The Conduct of Public Affairs II.

554 Seminar in Urban Government and Administration.

555 Towards the Resolution of Public Issues.

557-558 Seminar in Political Economy and Public Policy.

559 Science, Technology, and Public Policy.

560 Financial Management in Governmental Organization.

562 Comparative Local Politics.

750-751 Integrative Seminar: Education for Public Management Program.

### **Quantitative Analysis**

123 Quantitative Methods for Management.

125 The Computer and Decision Making.

600 Introduction to Probability Theory.

601 Introduction to Statistical Theory.

602 Operations Research I.

604 Operations Research II.

605 Multidimensional Measurement and Scaling.

606 Statistical Inference in Managerial Decisions and Research.

607 Bayesian Decision Theory.

950 Introduction to Management Information Systems.

951 Introduction to Computer Systems Analysis.

### **Research**

010 Directed Reading and Research.

905 Strategies for Organizational Research.

908 Research Seminar for Doctoral Candidates.

909 Social Psychology of Organizing.

### **Chemical Engineering**

**IHE561 (5621) Process Design and Economics.**

Selection, design, cost of process equipment. Market research and survey. Process development and design.

**IHE562 (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.

**IHE611 (5161) Phase Equilibria.**

Detailed study of pressure-temperature-composition relations in binary and multicomponent heterogeneous systems where several phases are of variable composition. Prediction of phase data.

**IHE621 (5741) Petroleum Refining.**

Critical analysis of processes employed in petroleum refining.

**IHE623 (5790) Consumer Products Engineering.**

Engineering functions in development of new consumer products. Interrelationship of research, marketing, manufacturing.

**IHE624 (5635) Marketing of Chemical Products.**

Examination of marketing activities, organizations, costs in the distribution of chemicals. A market research project required.

**IHE625 (5636) Economics of the Chemical Enterprise.** Research economics; feasibility studies; information services; venture analysis; depreciation; planning.

**IHE626 (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, market forecasting. Profitability calculations and projections.

**IHE627 (5760) Nuclear and Reactor Engineering.** Fuel processing and isotope separation, radioactive waste disposal, fuel cycles, radiation damage, biological effects and hazards, shielding, radiation chemistry.

**IHE629 (5642) Development Economics.** Planning, evaluation, and management of development activities in process industries as related to research, processing, new products, markets, long-range growth.

**IHE630 (5312) New Separation Techniques.** Discussion of new or less common separation techniques such as chromatography, ion exchange, electrophoresis, membrane operations; analysis, design, scale-up.

**IHE631 (5609) Mixing and Mechanical Separations.** Theory and application of mixing and mechanical separations involving fluids and solids.

**IHE640 (5742) Polymeric Materials.** Chemistry of polymerization reactions, manufacture and properties of synthetic resins, fibers, plastics, rubbers.

**IHE641 (5743) Properties of Polymeric Materials.** Mechanical, electrical, optical properties of polymers. Phenomenological aspects and molecular theories of non-Newtonian flow, viscoelasticity, ultimate tensile properties.

**IHE642 (5752) Polymeric Materials Laboratory.** Experiments in the formation, characterization, fabrication, testing of polymers.

**IHE643 (5770) Engineering Analysis of Physiological Systems.** Engineering analysis and mathematical description of flow, transport phenomena, chemical reactions involved in physiological system functions.

**IHE644 (5748) Fermentation Engineering.** Advanced discussion of fermentation as a unit process. Topics include sterilization, aeration, agitation, continuous fermentation.

**IHE645 (5749) Industrial Microorganisms.** A brief introductory course in microbiology for students with good background in chemistry.

**IHE646 (5903) Seminar in Biochemical Engineering.**

**IHE647 (5761) Topics in Bioengineering.** Analysis of transport phenomena, reaction kinetics, process dynamics and control, optimization in biological systems.

**IHE651-652 (5510-5512) Numerical Methods in Chemical Engineering I and II.** Application of computer methods to solution of complex chemical engineering problems.

**IHE653 (5780) Statistical Applications in Process Development and Design.** Application of statistical methods in interpreting laboratory and pilot-plant data; process quality control; design of experiments; uncertainties in design of process plants.

**IHE671 (5717) Process Control.** Dynamic response of processes and control instruments. Use of frequency response analysis, Laplace transforms, and electronic analogs to predict behavior of feed-back control systems.

**IHE672 (5750) Applied Surface Chemistry.** Applied aspects of surface chemistry and physics. Interactions at phase boundaries. Correlation of "critical surface tension" for solids with friction and wear, wetting, spreading and adhesion, biological phenomena.

**IHE680 (5851) Chemical Microscopy.**

**IHE681 (5857) Electron Microscopy.**

**IHE682 (5859) Advanced Chemical Microscopy.** Laboratory practice in special methods and special applications of chemical microscopy.

**IHE692-693-694 (5952-5953-5954) Research Projects.** Research on an original problem in chemical engineering.

**IHE695-696 (5955-5956) Special Projects in Chemical Engineering.**

**IHE711 (5105) Advanced Chemical Engineering Thermodynamics.** Application of the general thermodynamic method to advanced problems in chemical engineering.

**IHE712 (5107) Reactor Design.** Effects of heat transfer, diffusion, and nonideal flow on reactor performance. Optimum design for complex reactions.

**IHE713 (5109) Advanced Chemical Kinetics.** Reaction rate theory and application to complex reaction mechanisms; adsorption phenomena and application to heterogeneous catalytic reactions.

**IHE714 (5508) Diffusion in Membranes and Porous Solids.** Theories for diffusion of gases and liquids in porous solids and porous and dense membranes.

**IHE731 (5505) Advanced Transport Phenomena.** Integrated treatment of momentum, mass and heat transfer.

**IHE751 (5501) Methods of Chemical Engineering Analysis.** Methods of mathematical analysis of direct application to thermodynamics, transport phenomena, reactor design.

**IHE790 (5900) Seminar.** General chemical engineering seminar required of students majoring in the Field.

**IHE891-893-894 Thesis Research for Master of Science Degree.**

**IHE991-992-993-994-995 Thesis Research for Ph.D. Degree.**

## Chemistry

### **405 Techniques of Modern Synthetic Chemistry.**

Syntheses of complex organic and inorganic molecules carried out with emphasis on following techniques: vacuum line, high pressure, high temperature solid state, inert atmosphere, nonaqueous solvents, radioactive labeling, photochemical and electrochemical methods.

### **605-606 (505-506) Advanced Inorganic Chemistry.**

First term: introduction to group theory and its application to hybrid orbitals, molecular orbitals, molecular vibrations of small molecules. Recent advances in structure, bonding, 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.

### **625 (525) Advanced Analytical Chemistry I.**

Application of molecular spectroscopy to chemical problems. Topics: ultraviolet, infrared, NMR, Raman, mass spectroscopy.

### **627 (527) Advanced Analytical Chemistry II.**

Modern analytical methods, including electron, Mössbauer and Fourier spectroscopy; mass spectrometry; methods applicable to macromolecules; applications of on-line computers.

### **628 (528) Advanced Analytical Chemistry III.**

Modern analytical methods, including atomic spectroscopy, solids mass spectrometry, X ray and nuclear methods, separation techniques; applications of on-line computers.

### **650-651 Graduate Seminar in Organic Chemistry.**

Series of talks representative of all fields of current research interest in organic chemistry, given by research associates, faculty members, distinguished visitors. Normally attended by all organic majors.

### **665 (465) Advanced Organic Chemistry.**

Survey of simplest organic reactions within framework of a mechanistic approach. Provides skills and background needed to predict reactivity patterns and stereochemical preferences of new molecules in a variety of experimental environments. Qualitative applications of statistical thermodynamics and molecular orbital theory illustrated by readings from current research literature.

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

### **668 (468) Chemical Aspects of Biological Processes.**

Forms basis of chemical aspects of graduate program in molecular biology. Biochemical systems, bioenergetics, metabolic pathways.

### **672 (572) Mechanism of Enzyme Catalysis.**

Enzymes, coenzymes, model systems. Discussion of new physical methods for study of enzyme processes.

**677 (577) Chemistry of Nucleic Acids.** Properties, synthesis, reactions of nucleic acids.

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

**681 (481) Physical Chemistry III.** Discussion of advanced topics in physical chemistry, including introduction to principles of quantum theory and statistical mechanics, atomic and molecular spectra, elementary valence theory.

### **686 (586) Physical Chemistry of Proteins.**

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

### **700 Baker Lectures.**

### **701-702 (601-602) Introductory Graduate Seminar in Analytical, Inorganic, and Physical Chemistry.**

Weekly seminars on contemporary topics prepared and presented by first-year graduate students. 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.

### **716 (515-516) Selected Topics in Advanced Inorganic Chemistry.**

Topics vary from year to year.

### **765 (565) Physical Organic Chemistry I.**

Continues and extends the approach of 665 to more complicated organic reactions. Particular emphasis on applications of reaction kinetics and isotope effects to an understanding of reaction mechanisms.

### **766 (566) Physical Organic Chemistry II.**

Quantitative aspects of organic chemistry.

### **770 (570) Selected Topics in Organic Chemistry.**

Topics vary from year to year.

### **774 (574) Chemistry of Natural Products.**

Particular attention devoted to methods of structure determination and synthesis as applied to selected terpenes, steroids, alkaloids, antibiotics.

### **780 (580) Principles of Chemical Kinetics.**

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

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

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

**793 (593) Quantum Mechanics I.** Schrödinger's equation, wave packets, uncertainty principles, WKB theory, matrix mechanics, orbital and spin angular momentum, exclusion principle, perturbation theory, variational principle, Born-Oppenheimer approximation. At the level of Bohm, *Quantum Theory*.

**794 (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*.

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

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

## Chinese Literature

**213-214 Introduction to Classical Chinese.**

**314 Chinese Philosophical Texts.**

**320 T'ang and Sung Poetry.**

**401-402 History of the Chinese Language.**

**403 Linguistic Structure of Chinese: Phonology and Morphology.**

**404 Linguistic Structure of Chinese: Syntax.**

**405 Chinese Dialects.**

**411-412 Readings in Modern Chinese Literature.**

**413 Classical Chinese Prose.**

**416 Pre-T'ang Poetry.**

**419 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 Chinese Dialect Seminar.**

**509 Seminar in Chinese Folk Literature.**

## 521-522 Advanced Directed Reading

## City and Regional Planning

Courses for City and Regional Planning are offered by the Department of Policy Planning and Regional Analysis and by the Department of Urban Planning and Development.

### Policy Planning and Regional Analysis

Most courses in the Department of Policy Planning and Regional Analysis are open to students in any college of the University who have fulfilled the prerequisites and who have the consent of the instructor.

### Urban and Regional Theory

**710 (510) Introduction to Urban and Regional Theory.** First-year graduate course. Growth and structure of cities. Eclectic, borrowing theories from economics, sociology, and geography to explain size, functioning, location of cities and their components.

**719 (519) Informal Study in Urban and Regional Theory.**

**813 (613) Research Seminar in Urban and Regional Social Structure and Policy Analysis.** Advanced research seminar designed to discuss and investigate some of implications of urban and regional social structure on initiation, formulation, outcome of public policy. Students undertake their own exploratory research projects on this subject.

**814 (614) Urban Economics I.** Series of lectures presenting broad aspects of urban economic development and planning; complemented by original research work — in working groups. Groups report in seminars at approximately three-week intervals. Topics, presented in the light of central concern with political economy of metropolitan development and planning: organization of economic activity in space; economics of transport and industrial location; regional interactions and growth policies; urban transport and commuting problems; intrametropolitan industrial location trends; labor problems and migration; economics of construction industry; urban infrastructure; economics of housing and urban renewal; economics of urban services including education, health, police, fire, waste removal, general government; costs of social morbidity and social defense and welfare establishment; economics of pollution and environmental controls; problems of urban finance. Existing structures and institutions appraised from point of view of their overall social rationality. Impact of planning decisions on economic performance and distribution of income and political power analyzed. Special attention to problems of race, poverty, dual economy, urban ghetto.

**815 (615) Urban Economics II.**

**819 (619) Informal Study in Urban and Regional Theory.**

**914 (714) Metropolitan Land Use: Economic Analysis.** Housing market, land-use competition, location of retail, service, wholesale, manufacturing enterprises. Determination of land values and urban structure and form. Public controls, urban redevelopment, evaluation of social costs and benefits.

**915 (715) Location Theory.** Traditional Weberian location doctrine. Transport orientation, labor orientation, agglomeration, urban rent theory. Interregional trade and market and supply areas analysis. Particular attention paid to Loschian and Christaller systems of urban places. Dynamic aspects of location and urban theory explored, with particular emphasis on changing location and spatial distribution patterns.

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

**917 (717) Advanced Seminar in Urban and Regional Theory II.** Continuation of Planning 916 concentrating on recent developments.

**919 (719) Informal Study in Urban and Regional Theory.****Planning Theory and Policy Analysis**

**720 (520) Policy Planning and Collective Choice.** Examination of problems and prospects of strategic choice, planning and action in contexts in which allocation and redistribution processes are subject to direct constraints of collective choice and public policy. Fairly heavy emphasis on selection of appropriate forms and styles of planning and operationalization of conceptual schemes. Both theory-based and model-based frameworks for planning and policy development formulated, evaluated, subjected to actual and simulated reality tests.

**721 (521) Planning Theory.** Normative and behavioral models of decision making for provision of public goods and services. Theories of individual decision and choice reviewed, followed by applications in organizational context stressing impact of alternative organizational models on social decision processes.

**729 (529) Informal Study in Planning Theory and Policy Analysis.**

**820 (620) Planning and Organization Theory.** Seminar examining organizational and administrative models relevant to plan formulation and implementation. Hierarchy, control, specialization, representation, professionalization, organizational development examined within context of planning

theory and social system change. Applications made to such programs as community action, regional development, urban renewal, land-use control.

**821 (621) Politics of the Planning Process.**

Theories of planning process compared with concepts of political process and political change. Points of tension, overlap, and complementarity examined in context of city and regional planning and development agencies, intergovernmental relations, regulatory process, neighborhood and subregional development movements, national planning agencies. Alternative models for study of such institutions and processes assessed for their usefulness as guides to planners and researchers.

**822 (622) Techniques of Planning Implementation and Control.** Examination of one subset of new developments in analyzing interrelated activities. Discussion of two most well-known versions of network-based management control system—CPM (Critical Path Method) and PERT (Program Evaluation and Review Techniques). Use of digital computer simulation as a potentially powerful extension of these systems.

**824 (624) Organizational Change and Public Service Delivery Systems.** Examination of operation of urban political system and policy-making process with emphasis on service outcomes of local public bureaucracies in education, health, welfare, manpower, police, environmental protection fields. Community organization, citizen participation, new careers, decentralization, community control analyzed from perspective of organizational change.

**829 (629) Informal Study in Planning Theory and Policy Analysis.**

**920 (720) Seminar in Planning Theory.** Survey of works of scholars who have contributed to current thinking about planning theory. Alternative assumptions concerning models of man and theoretical concepts concerning nature of planning today.

**929 (729) Informal Study in Planning Theory and Policy Analysis.****Methods for Planning Analysis**

**730 (530) Mathematical Concepts for Planning.** Introductory course for students having little or no background in college mathematics. Basic concepts in matrix algebra, calculus, probability covered in self-contained units of one credit hour each. Students may register for any or all topics.

**731 (531) Statistical Analysis for Planning.** Introduction to basic methods of statistical analysis with emphasis on their use in decision-making process in planning. Material in decision theory, sampling, estimation, hypothesis testing, prediction introduced.

**733 (533) Planning Analysis.** City planning applications of general analytical techniques of social science, population, economic, spatial models.

**736 (536) Introduction to Computers in Planning.**

Introduction to use of computers in problem-solving and planning processes. Students run programs on Cornell computer using PL/1 or another appropriate programming language. Brief introduction to computer systems and use of library routines. Advantages and limitations of using computers considered.

**739 (539) Informal Study in Planning Analysis.**

**830 (630) Planning Public Investments.** Detailed and rigorous examination from point of view of theory and practice of selected methods and techniques of analysis used in planning and evaluation of public investments. Primary focus discussion of benefit cost-analysis, cost effectiveness analysis, capital budgeting; integration of these methods in planning-programming budgeting systems.

**839 (639) Informal Study in Planning Analysis.**

**930 (730) Special Topics in Methods for Planning and Policy Analysis.** Review and critical analysis of various analytical and computer methods of actual and potential use in planning and in analysis of public policy. Material covered varies each semester depending upon interests of members of seminar. Topics selected at first meeting of semester.

**932 (732) Techniques of Regional Accounting.**

Methods of construction of regional, social accounts and their application to regional planning. Measuring levels of activity within regions such as income and product accounts emphasized; methods of estimating flows between regions such as balance of payment accounts.

**933 (733) Methods of Regional Analysis.**

Advanced applications of interregional and regional input-output and linear programming techniques to development problems. Applications of spatial interaction and growth (intertemporal) models to analysis of urban and multiregional systems, with particular reference to environmental quality management.

**939 (739) Informal Study in Planning Analysis.****Planning Institutions, Programs, and Practice****740 (540) Introduction to Planning Institutions.**

Survey of contemporary organizational forms and political forces facilitating and inhibiting the development of planning at city, state, regional level. Development of planning practice in areas of urban land use, regional economic development, health and welfare, other services. Subnational planning in U.S.; national context and other nations are dealt with where appropriate.

**741 (541) Planning Practice.** Application of planning principles and techniques to community situations including working with town and county governments and planning officials to analyze and evaluate community conditions, problems, goals,

priorities, resources, activities. Development of comparative frameworks for policy analysis.

**742 (542) Internship in Planning and Policy Analysis.****840 (640) Field Problem in Planning Methods.**

Opportunity to apply theories and techniques of analysis and planning to real problem situations. Some have opportunity of working with low-income groups and developing an understanding of how planners can serve such clientele. Work carried out in cities and towns convenient to Ithaca. Others work on plans and programs related to efforts of official planning agencies. Developed primarily for graduate students in other departments, but any nondepartmental student who may wish to enroll should contact faculty members in charge.

**841 (641) Field Problem in Planning Methods.**

Follow-up of work begun in PPR 840 to provide continuous planning services to client groups. PPR 840 not prerequisite.

**844 (644) Design and Conservation.** Rationale for and methods of utilizing existing cultural and aesthetic resources in planning and design of regions and cities.

**845 (645) Documentation for Preservation Planning.**

Methods of collecting, recording, processing, analyzing architectural and cultural survey materials.

**849 (649) Informal Study in Planning Practice.****949 (749) Informal Study in Planning Practice.****Urban and Environmental Systems Planning****751 (551) Planning Information Systems.**

Consideration of methods and techniques for design and use of computer-based information systems in planning. First part: data structures and issues related to use of data banks for planning purposes. Second part: use of simulation in planning. Techniques and applications introduced. Students expected to run their own programs on Cornell computer.

**852 (652) Environmental Health Planning.**

Introduction to concepts and issues in environmental health planning. Topics: planning problems involved in control of water quality, liquid and solid waste disposal, air quality, housing quality.

**853 (653) Planning and Evaluation of Environmental Health Programs and Projects.**

Examination of use of quantitative methods and economic analysis as aids to social decision making with regard to action in area of environmental health. Exposes students who already possess a methodological competence to application of these methods in study of particular problems of environmental health. Topics: rational social decision making and environmental health, economics of environmental quality management; investment models for size and location of regional systems of waste treatment, water treatment and solid-waste-disposal facilities; selected mathematical

and statistical models used to describe, explain, or identify selected environmental health problems.

**854 (654) Systems Analysis in Urban Policy Planning.** Examination of existing and potential uses of systems analysis in policy planning issues. Advantages and limitations of uses of systems analysis methodology in public policy planning. Special emphasis on policy aspects of urban problems. Applications of systems analysis to policy questions. May include among other issues housing, education, health, social services.

**859 (659) Informal Study in Urban Systems Planning.**

**959 (759) Informal Study in Environmental Health Planning.**

### **Regional Economics and Development Planning**

**860 (660) Introduction to Regional Development Planning.** Focuses on problems of and theories about development of lagging, underdeveloped, or poor regions of industrial nations. Readings survey various theoretical works upon which regional development planning is, or ought to be, based. Latter parts of course deal with difficult transition from theory of planning recommendations and policy implementation. Brief case studies used for illustration.

**863 (663) Regional Planning and Development in Developing Countries.** Selected theories and development problems from PPRA 860 elaborated, deepened, applied. Several extensive case studies of development planning analyzed and evaluated with those theories and with criteria suggested by them. Process of regional development through urbanization and in particular concepts of equity and efficiency, external economies, export linkages, internal self-sufficiency and integration. Resource development, national integration, human development, migration problems.

**869 (669) Informal Study in Comparative Planning.**

**963 (763) Planning Techniques for Developing Regions and Small Nations.** Simulation of work of consulting team's proposals and analyses of policies for development of various sectors and problem areas, e.g., manufacturing, agriculture, health, education and services, infrastructure, urbanization, exports. Problem approached with as much realism as possible in academic setting, with concentration on particular region. Final product is set of plans. Requirements include minimal general reading, extensive research on topic of interest, an interim written and verbal report on research, written final report, including proposals, to be summarized in verbal presentation.

**969 (769) Informal Study in Regional Planning.**

### **Social Planning, Health Systems, and Housing**

**770 (570) Introduction to Social Policy.** Intended as introduction to fundamental issues of social policy

analysis. Alternative approaches to social policy analysis outlined; analytical framework to manpower, social service, education, income maintenance policies developed and applied. Social policy issues viewed within context of both traditional and emergent theories of inequality. Emphasis on limitations of contemporary welfare-state social programs in reducing inequality.

**773 (573) Urban Social Planning.** Seminar in theory, process and methodology of social planning in complex urban systems. Analysis of social planning functions not restricted to those areas of concentration that have normally been regarded as purview of city planning profession. In examining social planning concepts and behavior of individuals and agencies in different planning contexts, focus is on microstructural and macrostructural impact and ramifications of certain types of nonobvious social planning.

**779 (579) Informal Study in Housing Plans and Programs.**

**871 (671) Seminar in Social Policy Research and Analysis.** Examination of contemporary methods of social policy analysis, especially their ideological implications, and developing multidisciplinary approaches to selected social policy issues. Dilemmas of action research and of implementing research findings explored.

**874 (674) Seminar on Mental Health Planning.** Seminar discussions of development and performance of institutions for care of emotionally disturbed, including mental illness, drug abuse, alcoholism. Program approaches, philosophies and assumptions of clinical and community care analyzed. Emphasis on planning for processes and spatial aspects of prevention of disorders, using case studies and existing research as foundation. Limited enrollment.

**876 (676) Urban Housing.** Seminar in housing analysis and policy development with specific emphasis on problems and prospects of urban housing sector. Interfaces economic, social, and institutional forces underlying housing demand and supply with real-world problem-solving. Exercise in housing data analysis and policy formulation.

**877 (677) Seminar in Comprehensive Health Planning.** An integrative seminar on comprehensive health planning designed especially for students in city and regional planning, sociology, and the Sloan Institute of Hospital Administration. Focuses on contemporary issues, thus attempting an interdisciplinary approach to study of planning, organization, and delivery of health services and to demonstrate relations between theoretical and practical aspects of comprehensive health planning. Social, economic, and political considerations of health planning endeavor, and technical and organizational developments analyzed and discussed from conceptual and pragmatic standpoint. Wherever possible, health planning comparisons with other countries drawn from literature.

**879 (679) Informal Studies in Social Planning.**

**970 (770) Colloquium in Social Policy Theory and Practice.** Graduate and faculty level seminar in social policy planning. Each year major area or issue in social policy explored from many perspectives: theoretical, empirical, political, professional, ethical, moral. Discussion papers and presentations sought from faculty, students, campus visitors.

**979 (779) Informal Study in Health Systems Planning.****Planning Research****898 (698)-899 (699) Thesis Research.**

**990 (790) Planning Research Colloquium.** Presentation and discussion of current departmental research.

**999 (799) Dissertation in Urban and Regional Planning.** Advanced independent research by candidates for Ph.D. degree.

**Urban Planning and Development**

Most courses in the Department of Urban Planning and Development are open to students in any college of the University who have fulfilled the prerequisites and who have the consent of the instructor.

**Historical Development of Urban Areas**

**401-501 (400-500) Historical Development of the World's Cities I.** Historical methods and research techniques; case studies and aesthetic evaluation; urban revolution; classical societies; medieval urbanism; Renaissance and the baroque in Europe; colonization and North America.

**402-502 (401-501) Historical Development of the World's Cities II.** Introduction: social, philanthropic, and planning movements from 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.

**504 (603) Seminar in the History of American City Planning.**

**602 (701) Seminar in American Urban History.** Seminar in historical evolution of the American city. Emphasis on factors in urban growth, process of urbanization, urban reform movement, intellectual and social responses to the city.

**809 (609) Informal Study in the Historical Development of Urban Areas.** Master's level.

**909 (709) Informal Study in the Historical Development of Urban Areas.** Ph.D. level.

**Urban Planning Principles, Theory, and Process****511 (410-510) Introduction to Concepts and Principles of Urban Planning and Development.**

Examination of city plans and city planning in U.S. from period of colonization to present time. Following a survey of history of American planning, major problems of city development and solutions advanced to improve urban conditions reviewed. Major emphasis on issues involving physical development. Student introduced to related social, political, economic, and legal matters with which modern urban planning is concerned. Lectures, seminars, reading, and research papers.

**512 (514) Urban Economic Analysis.** 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, social and economic costs and benefits, location of residential and industrial areas and retail centers. Also, interregional location theory and review of various techniques of selecting optimum locations, effects of new plants upon regional development, economic problems of declining open regions. Knowledge of mathematics and of modern quantitative methods not a precondition for admission, but ability to master them during course assumed.

**513 (412-512) Introduction to Human Ecology.**

Examination of processes and forms of man's adaptation of and to the physical environment. Major focus on urban society. Concept of an ecosystem rigorously examined from perspectives of biological ecology, cultural anthropology, and urban sociology. These three perspectives provide increasingly complex examples of role of organization in adaption of activity to territory. Imbalanced ecological relationships and organizational impact of this imbalance considered through examination of agricultural methods, and by examining energy production and waste disposal. Brief overview of regional interactions between cities provides introduction to complexities of applying biological models to sociological reality. Examination of invasion, succession, and competition within metropolitan areas provides greater depth. Readings include literature representative of current ecological crisis. Students asked to apply understanding gained to propose solutions to specific planning-related problems. Lectures, discussions, readings, field trips, research papers.

**515 (518) Community Development Processes and Programs.**

Examination of processes of development of community groups and their urban neighborhoods. Policies and development strategies selected and effectiveness of programs. Role that urban minority groups play in planning and implementation of programs aimed at upgrading the quality of their life and environment. Attention to federal and local programs designed specifically for use by community groups within a larger metropolitan setting. Field work with existing community groups.

**612 (611) The Urban Development Process.**

Examination of goals, strategies, methods, achievements of major participants in urban land and building market: land owners, speculators, real estate brokers, developers, bankers, lawyers, nonprofit builders, government agencies. Visitors representing these fields of activity discuss their roles and functions in urban development process, identify limits on their powers of decision making, and indicate how their actions affect others. Assigned readings, seminars, field trips.

**614 (610) Neighborhood Theory.** Empirical investigations of neighborhood satisfaction, cohesion, and organization. Examination of concept of neighborhood in urban society. Some theoretical orientation placing neighborhoods in context of larger urban society reviewed. Impact of physical design and natural landscape on these three topics considered in depth. Review of neighborhood oriented aspects of "War on Poverty," public housing, and urban renewal. Class designs and executes one piece of research (generally of a laboratory nature) exploring these topics.

**711 (712) Seminar in Ecological Research.**

Introduction to instructor's ongoing investigation of neighborhood groups involved in combating land development in midwestern city. After consideration of sociological literature in neighborhood satisfaction, neighborhood interaction, and community organization, students take on specific research assignments using compiled data.

**712 (710) Special Topics in Urban Sociology.**

Advanced reading seminar in urban sociology. The class with instructor decides on a general subarea relevant to planning concerns. Class divides into groups; each attacks a specific body of literature. Weekly meetings consist of presentations by each group and general discussion. Class is aided in this discussion by annotated bibliographies prepared by each group. In addition to studying the work itself the group is responsible for researching professional biographies of authors considered so that an understanding of process of intellectual growth can develop.

**819 (619) Informal Study in Urban Planning Principles, Theory, and Process.** Master's level.**919 (719) Informal Study in Urban Planning Principles, Theory and Process.** Ph.D. level.**Methods and Techniques of Planning Analysis**

**421-521 (420-520) Introduction to Quantitative Techniques in Urban Planning.** Basic coverage of urban planning applications of population and migration studies, regional economic description methods, regional social accounting including income and product, balance of payments, money flows, interindustry and wealth accounts, theories and methods of forecasting urban growth, land use, transportation models. Knowledge of mathematics not a precondition for admission but ability to master some during course assumed.

**522 (523) Methods and Techniques of Urban Land-Use Planning.**

Surveys, analyses, plan-making techniques for use in guiding physical expansion and renewal of urban areas; location requirements, space needs, interrelationships of various classes of land use with special emphasis on residential, commercial, industrial activities and community facilities; standards and survey methods for determining housing conditions and quality of residential environment.

**524 (527) Workshop in Heuristic Gaming**

**Techniques.** Students introduced to large variety of urban and social simulation games; they learn how to administer such games, create modifications of existing games, and build their own.

**622 (522) Methods of Field Research in Urban Planning.**

Practicum in social survey techniques. Students isolate an important research question applicable to planning problems in Ithaca area; design a questionnaire, administer it, code and analyze data, prepare and present a report. Fundamentals of questionnaire construction, interviewing techniques, sample design, index construction, general survey administration, data analysis covered.

**721 (620) Seminar in Regional Social Accounting.**

Advanced seminar in methods of construction and regional application of social accounting. Topics: income and product accounts, balance of payments, money flows, wealth accounting. Extensive references made to methods used in various countries and to recent regional case studies.

**821 (724) Seminar in Regional Development**

**Models.** 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- and multisector models.

**822 (721) 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.

**824 (725) Econometric Methods in Regional**

**Planning.** Dynamic elements in regional models, treatment of time, depreciation, replacement, 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.

### Planning and Development Controls and Implementation

#### 531 (632) Suburbanization and New Communities.

Investigation of metropolitan growth patterns and use of regional open space in shaping form of urban development, concentration on major issues involved in suburban development and role of new communities in accommodating expected future population. Historical and contemporary examples of new towns programs in U.S. and abroad examined, and current and proposed state and federal legislation reviewed. Seminars, assigned reading, research papers.

#### 533 Environmental Control Systems (Architecture 662).

Man-environment systems approached from two viewpoints: as physical structures and devices; and as social arrangements, laws, culture. Through method of continuing debate two instructors critically analyze present methods of pollution and environmental control in cities. Laboratory sessions attempt to actualize these viewpoints through physical models and simulation exercises. Entire class participates in term project.

#### 631 (630) Urban Land Policy and Programs.

Consideration of major problems of urban land control and management and possible solutions. Subjects for discussion include taxation as method of land-use planning, compensation and betterment, large-scale public land acquisition, subsidies and incentives, acquisition of development rights or easements. Several public planning systems of other countries studied, contrasted with U.S., and evaluated.

**632 (531) Legal Aspects of Planning.** Legal aspects of preparing and administering zoning ordinances, subdivision regulations, housing codes, official map regulations, related subjects.

#### 839 (639) Informal Study in Planning and Development Controls and Implementation.

Master's level.

#### 939 (739) Informal Study in Planning and Development Controls and Implementation. Ph.D. level.

### Physical and Aesthetic Aspects of the Urban Environment

#### 541 (540) Introduction to Environmental Planning and Design.

Introduction to basic concepts and issues of environmental planning and design. Topics: structure of space and function and interrelations between them within context of a range of designed and undesigned environments. Basic techniques of representation (graphic and nongraphic), analysis, modeling reviewed and understanding of design process developed. No previous training in design required.

**542 (541) Planning Design.** Analysis of requirements of program and context and their reformulation as determinants of spatial organization. Emphasis on development of spatial concepts based on prepared evaluation of the site, taking into consideration the influences of functions, culture and life styles, other ecological factors, and development

of framework for evaluating nonphysical implications of existing physical-spatial organizations in different environmental contexts. Necessary theories, methods, techniques of planning design introduced in 541 elaborated upon and applied in studio problems.

**641 (640) Seminar in Urban Design.** Investigation of historical and current thought on visual aspects of cities, including evaluation of technological and cultural influences on urban design, perception of urban form, relationships between contemporary city planning process and visual form in cities.

#### 849 (649) Informal Study in Physical and Aesthetic Aspects of the Urban Environment. Master's level.

#### 949 (749) Informal Study in Physical and Aesthetic Aspects of the Urban Environment. Ph.D. level.

### Urban Renewal and Housing

#### 452-552 (451-551) Introduction to Government Programs for Urban Renewal.

Survey course reviewing development of governmental policy in urban renewal field. Presentation of major governmental programs at federal and state levels aimed at renewing and developing cities and improving housing conditions in U.S. Several important case studies examined.

**551 (653) Social Facilities for Large Scale Housing Developments.** Analysis of special problems in urban design and in provision of community facilities resulting from current encouragement of industrial methods, scale, speed in housing. Concentration on social requirements encountered in large-scale developments and administrative procedures by which these requirements may be met. Experience in European countries, where government agencies directly administer such developments, cited.

#### 652 (651) Urban Politics and Planning.

Consideration of political dimension of planning and renewal activities. Emphasis on governmental mandate and structure, and interest group and power relationships as they are related to developmental decision-making processes. Theory and case study analyses.

#### 859 (659) Informal Study in Urban Renewal and Housing. Master's level.

#### 959 (759) Informal Study in Urban Renewal and Housing. Ph.D. level.

### Institutional and Public Facilities Planning

**562 (661) Institutional Planning.** Seminar in programming and area planning of facilities for institutions including universities, medical centers, churches. Administrative organization, space use studies, program development, location and function analysis, enrollment projection, institutional systems.

Application of city planning techniques to institutional planning.

**869 (669) Informal Study in Institutional and Public Facilities Planning.** Master's level.

**969 (769) Informal Study in Institutional and Public Facilities Planning.** Ph.D. level.

**Urban Planning Fieldwork and Practice**

Field work in urban planning and development problems may be taken upon completion of appropriate academic course and approval of instructor of course. In certain cases appropriate course may be taken at same time as field work. If proposed field work is not part of regularly organized field work course, arrangements for faculty supervision and evaluation of field work must also be approved in advance.

**570 Comprehensive Planning Workshop.**

Research and analysis in an urban area leading to preparation of comprehensive and functional area plans and effectuation programs; lectures, field trips, and individual and group reports.

**572 Community Facilities in Large-Scale Developments.** Fieldwork section for UPD 551.

**573 (574) Community Organization Workshop.**

Designed for students who intend to work with community groups. Presentation of two theoretical approaches to community organization and practical implications of each to the professional committed to intervention. A workshop to teach detailed methods of working with community groups including process recording, planning interventions, working with groups split by factions, professional use of self and use of resources outside community. Ethical problems inherent in this kind of work extensively discussed. Students engage in several group observations and play relevant simulation games.

**574 (572) Program Planning for Minority Groups.**

Will familiarize students with practical problems of organization, planning, programming, development of an urban minority community action group. Students offered opportunity: to apply planning skills to help such a group define and meet the needs of its people; to learn more about a specific minority group, and to begin to understand cultural, social, and other characteristics of such a population.

**575 Historic Area Preservation.**

Preparation of surveys, analyses, plans and programs for preservation of historic areas of small or large communities.

**576 (578) Urban Communications Workshop.**

Methods and techniques for developing community information networks for presentation and understanding of urban planning and development problems, policies and programs. Special attention given to use of television media and newspapers in cooperation with local facilities in Ithaca area.

**579 Special Problems in Field Work.**

Arrangements for enrollment and credit made with agreement of faculty member and with approval of entire UPD faculty.

**770 (672) Internship Program in Urban Planning and Development.**

Summer internship in New York metropolitan area in public or private planning, housing, urban renewal and development agencies. Positions also available in various functional agencies dealing with transportation, recreation, water resources, etc. Occasional openings with citizen groups and private consulting firms. Full-time work at current salaries supplemented with evening lectures and discussions two evenings a week. Several field trips in New York area and to other east coast cities. (Instruction period for course in the New York program limited to July and August.)

**772 (674) Internship Program at the Newark Urban Institute.**

Involvement in planning policy formulation and administration of a large American city. Philosophies and techniques of managing public programs in urban communities. In residence in city of Newark. Students assigned as full-time staff members in various city departments or agencies where they have direct responsibility for defining a project, identifying problems, preparing alternative solutions, planning new and innovative programs and policies. Supervision provided primarily by members of staff of city of Newark. Participation in academic courses offered on site in Newark by faculty members from consortium of universities cooperating in Institute program.

**Landscape Planning and Design**

**581 Landscape Planning and Design Workshop.**

Project-oriented. Designed to integrate various disciplinary and professional skills in designing environmental modifications that optimize relationships with ecological systems. Various elements of land modification process addressed, including suitability-impact analysis, planning, design, management. Intended to heighten student awareness of ecological systems factors in planning and design, to develop skills in practical analysis and synthesis of data and in verbal and visual communication of alternatives to a client group. Orientation to a real client group compels awareness of temporal and economic constraints and serve as introduction to project administration.

**582 Landscape Planning and Design Workshop.**

Continuation of work undertaken in UPD 581.

**682 Social Factors in Landscape Design.**

Introduction to use of social science findings and structured observational techniques in landscape design. User behavior in local open spaces observed, analyzed, evaluated. Assessment of quality of existing local open spaces leads to design of space which emphasizes safety and utility among other user needs.

**Urban Planning and Development Research**

**790 (690) Special Projects in Urban Planning and Development.**

**890 (790) Planning Research Seminar.**

**899 (699) Thesis in Urban Planning and Development.**

**999 (799) Dissertation in Urban Planning and Development.**

## Civil and Environmental Engineering

**IIA380 (2480) Engineering Surveying and Evaluation.** Survey. Basic principles of geometric measurements including errors and adjustment. Modern surveying instruments and procedures for measuring and laying out angles, distances, areas, volumes. Use of coordinate systems and modern mapping methods for acquisition and display of earth resources data. Evaluation. Significance of several components of physical environment in engineering projects. Assessment of information about these components from maps, airphotos, ground data. Land inventory systems.

**IIA681 (2481) Photogrammetry.** Principles of terrestrial, aerial, space photogrammetry; geometry of a photograph, tilt and relief displacements, parallax distortions, control requirements, flight planning. Stereo plotting; relative and absolute orientation.

**IIA682 (2482) Analytical Aerotriangulation.** Coplanarity and colinearity mathematical equations for performing spatial solutions for resection and orientation for a single photo, stereo pair, triplet, strip, subblock, and block coverages of various types of surfaces for which positioning is sought.

**IIA683 (2483) Geodesy.** Future of earth and precise determination of position on or near earth's surface. Fundamentals of geometric geodesy, geodetic astronomy, physical geodesy, satellite geodesy, map projections.

**IIA685 (2485) Physical Environment Evaluation.** Study of physical environment and resources factors affecting engineering and planning decisions and evaluation methods of these factors. Physical factors include climate, soil and rock conditions, water resources in different parts of world. Evaluation methods include field reconnaissance, interpretation of meteorological, topographic, geological, and soil maps; aerial photography, engineering data, and subsurface exploration records. Display and presentation.

**IIA686 (2486) Advanced Physical Environment Evaluation.** Study of physical environment and resources by use of airphotos and other remote sensing methods. Conventional photography, sequential photography, multiple spectral photography, space photography, infrared thermal, radar imageries included in study. Evaluation of environment directed to planning of engineering and development projects in general, with some

emphasis on those related to special climatic regions such as arctic, tropical, humid, arid regions.

**IIA687 (2487) Analyses and Interpretation of Aerial Photographs.** Methods of identification of a broad spectrum of soils, rocks, drainage conditions and significance of vegetative and cultural patterns of world. Natural resources inventories and specific fields of application emphasized.

**IIA688 (2488) Advanced Interpretation of Aerial Photographs.** Lectures and team projects in laboratory and field. Facilities include material for city-regional planning, soil mapping, conservation, ground and surface water, civil engineering projects.

**IIA689 (2489) Remote Sensing.** Sensing and sensors in the electromagnetic spectrum with special emphasis on thermal and radar sensing. Project planning, imagery geometry, data acquisition, manipulation, display. Supporting ground investigation. Analysis and interpretation of images.

**IIA691 (2491) Design Project.** Design problems frequently associated with Master of Engineering program.

**IIA692 (2492) Research.** For students who wish to study one particular area in depth. Work may take form of a laboratory investigation, field study, theoretical analysis, development of design procedures.

**IIA693 (2493) Seminar.** Presentation and discussion of technical papers and current research in general field or one of its specialized fields.

**IIA694 (2494) Special Topics.** Supervised study in small groups on one or more special topics not covered in regular courses. Special topics may be of theoretical or applied nature.

**IIA696 (2496) Seminar in Remote Sensing.** Presentation and discussion of current research and development in remote sensing. Lectures by Cornell staff members and by invited specialists from government and industry.

**IIB203 (2205) Social Implications of Technology.** Some issues pertaining to development, implementation, assessment of technology presented. Emphasis on social, political, economic aspects of current problems which have important technological components. Technical background developed to extent necessary for an intelligent consideration of policy alternatives. Students required to do extensive reading and may be required to participate in case studies or write a term paper.

**IIC302 (2302) Hydraulic Engineering.** Free surface and pipe flow, fluid meters and measuring devices, hydraulic machinery, unsteady flow, waste heat discharges into lakes and rivers, applications of fluid mechanics. Laboratory includes a number of experiments in fluid mechanics and hydraulic engineering.

**IIC609 (2309) Descriptive Hydrology.** Introduction to hydrology as a description of hydrologic cycle and role of water in natural environment. Topics:

precipitation, infiltration, evaporation, ground water, surface runoff, floods, droughts.

**IIC612 (2312) Experimental and Numerical Methods in Fluid Mechanics.** Emphasis on planning and conducting laboratory and field experiments and on numerical computation.

**IIC615 (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, hodograph methods.

**IIC617 (2317) Free-Surface Flow.** Formulation of free-surface equations and boundary conditions. Shallow water theory and theory of characteristics. Unsteady and two-dimensional flow in open channels.

**IIC618 (2318) Dynamic Oceanography.** Statics and dynamics of oceans and lakes. Currents in homogeneous and stratified bodies of water. Tides, seiches, waves, tsunamis. Turbulence and diffusion.

**IIC620 (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.

**IIC691 (2391) Project.** Students may elect a design problem or undertake design and construction of special equipment in fields of fluid mechanics, hydraulic engineering, or hydrology.

**IIC693 (2393) Hydraulics Seminar.** Current topics in fluid mechanics, hydraulic engineering, and hydrology.

**IIC694 (2394) Special Topics in Hydraulics.** Special topics in fluid mechanics, hydraulic engineering, or hydrology.

**IIC716 (2316) Advanced Fluid Mechanics II.** Exact solutions to the Navier-Stokes equations, the laminar and turbulent boundary layers, turbulence, introduction to non-Newtonian flow, other topics.

**IIC721 (2321) Flow in Porous Media.** Fluid mechanics of flow through porous solids. General equations of single phase and multiphase flow and methods of solving differential form of these equations. Hydraulics of wells, infiltration, ground water recharge, other steady state and transient seepage problems in fully and partially saturated materials.

**IIC792 (2392) Research in Hydraulics.** An area of investigation in fluid mechanics, hydraulic engineering, or hydrology may be selected. Work may be either of an experimental or theoretical nature. Results should be submitted to instructor in charge in form of research report.

**IID606 (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, settlement. Design of shallow and deep foundations, footing, raft, caisson, pile foundations. Problems of construction and stability of excavations. Influence of groundwater flow on walls, foundations, excavations.

**IID610 (2410) Engineering Properties of Soils.** Natural environments in which soils are formed; 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.

**IID616 (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.

**IID631 (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.

**IID632 (2432) Highway Engineering (Agricultural Engineering OAE491).** Emphasis 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.

**IID645 (2445) Field Practice in Geotechnical Engineering.** 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 a requirement. Engineering construction practices and site evaluation related to landslides, bedrock, drainage, unstable soils. Influence of rock types, groundwater, soil materials on existing structures; appropriate design procedures at difficult sites.

**IID691 (2491) General Design Project in Geotechnical Engineering.** Design problems frequently associated with the Master of Engineering program.

**IID693 (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.

**IID694 (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.

**IID712 (2412) Graduate Soil Mechanics Laboratory.** Laboratory measurement of soil properties: classification tests; direct shear tests; triaxial tests for measurement of pore water pressure; strength parameters. Pore pressure dissipation tests. Relationship of laboratory tests to field behavior.

**IID714 (2414) Advanced Geotechnical Engineering.** Review in more detail of topics covered in IID606 with additional discussion of recent improvements. Topics: 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.

**IID715 (2415) Soil Dynamics.** Introduction to principles of vibration of simple systems under harmonic and transient loading. Energy propagation by waves through solid and layered systems. Detailed consideration of response of soils to dynamic and repeated loading; measurement of these characteristics. Analytical models of simple foundations on elastic media and analogues useful for design. Analysis and design examples.

**IID718 (2418) Case Studies in Soil Mechanics and Foundation Engineering.** Study of real engineering problems of various types; importance of geological environment in recognizing nature of field problems; application of mechanics and soil properties to obtain engineering solutions. Preparation of engineering reports.

**IID792 (2492) Research in Geotechnical Engineering.** For students who wish to study one particular area of geotechnical engineering in depth. Work may be a laboratory investigation, field study, theoretical analysis, or development of design procedures.

**IIE602 (2502) Water Quality Engineering.** Introduction to water quality engineering, including water supply, water and waste water treatment and disposal. Principles applicable to 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.

**IIE610 (2510) Chemistry of Water and Waste Water.** Principles of physical, organic and inorganic chemistry, biochemistry applicable to understanding, design, control of water and waste water treatment processes, and to reactions in receiving waters.

**IIE611 (2511) Aquatic Chemistry.** Chemical equilibrium in natural aquatic systems, including water and waste water treatment systems. Chemical thermodynamics, acid-base systems, oxidation-reduction systems, coordination chemistry, solid-liquid-gas interfaces with regard to precipitation, dissolution, adsorption. Emphasis on phenomena, mathematical solution of chemical equilibrium,

application to engineering management of water quality.

**IIE613 (2513) Biological Phenomena and Processes.** Theoretical and engineering aspects of biological phenomena and processes applicable to removal of impurities from water, waste water, industrial wastes, and to their stabilization in receiving waters. Pertinent microbiological principles, biological oxidation, kinetics, eutrophication. Analysis and design of biological treatment processes. Laboratory studies of pertinent phenomena and processes.

**IIE614 (2514) Chemical and Physical Phenomena and Processes.** Theoretical and engineering aspects of chemical and physical phenomena and processes applicable to removal of impurities from water, waste water, industrial wastes, and receiving waters including reaction kinetics, transfer and dispersion phenomena, fine particle mechanics. Analysis and design of conventional and advanced treatment and disposal processes. Laboratory studies of pertinent phenomena and processes.

**IIE615 (2515) Water Resources Problems and Policies.** Comprehensive approach to water resources planning and development. Historical and contemporary perspectives of water resource problems, organization, policies.

**IIE620 (2520) Environmental Quality Control.** Introduction to environmental pollution problems, their nature and dimensions, their impact on man. Principles and methods underlying environmental quality control; engineering, environmental health, regulatory and technological aspects of control. Emphasis on standards and legislation pertaining to control of solid wastes and air and water quality.

**IIE630 (2530) Solid Waste Management.** Study of municipal, industrial, agricultural solid waste. Emphasis on waste characteristics; methods of treatment and disposal; interrelationships with air, water, land environment.

**IIE631 (2531) Industrial Waste Engineering (Agricultural Engineering OAE676 (506)).** In three parts: (1) Consideration of legal aspects, assimilatory capacity of receiving waters, joint industry-municipal collection of wastes, sewerage service charges; (2) waste sampling and analysis, treatment processes, waste-reduction possibilities, water quality and quantity, reuse and recovery, costs; and (3) specific industrial operations and selected case studies of industrial waste treatment. An in-depth study of a particular waste problem required.

**IIE633 (2533) Environmental Quality.** Introduction to environmental quality and pollution problems, their nature, causes, control. Man's interaction with the air-land-water resource. Engineering and regulatory aspects of environmental quality management, with emphasis on control of air quality, water quality, solid wastes.

**IIE634 (2534) Air Quality Control.** Introduction to air quality and air pollution problems. Sources, natures, effects of specific air pollutants, their

dispersion interactions in the atmosphere. Air quality standards, regulations, legislation. Air quality control methods and technology.

**IIE645 (2545) Water Resources Planning Seminar.** Concepts, processes, techniques of regional, multipurpose river basin planning and development. Case study method used, with preparation of an integrated, comprehensive report for study area.

**IIE693 (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.

**IIE718 (2518) Water Resource Systems.** Application of economics, engineering, systems theory to water, waste water, related resource planning and management. Development of deterministic and stochastic models. Review of current literature.

**IIE791 (2591) Design Project.** Students elect or are assigned problems in the design of water and waste water treatment processes of plants; waste water disposal systems; water quality control systems; water resource development or management systems; or laboratory apparatus of special interest.

**IIE792 (2592) Sanitary Engineering Research.** Study of a special topic or problem in greater depth than is possible in formal courses.

**IIE794 (2594) Special Topics in Sanitary and Water Resource Systems Engineering.** Supervised study in special topics not covered in formal courses.

**IIF605 (2605) The Law and Environmental Control.** Introduction to structure and operation of legal system and manner in which it may handle environmental problems. Interaction of law and science; regional problems and political jurisdictional boundaries; police power of states; statutory law and case law; judicial function; nature and functions of administrative agencies; environmental regulation; recent environmental case law; interstate compact.

**IIF606 (2606) Seminar In Technology Assessment.** Interdisciplinary seminar dealing with social consequences of future technological development and means by which technology can be guided in socially beneficial directions. Student/faculty task forces undertake projects exploring aspects of technology assessment theory and methodology, perform simple assessments, or investigate questions pertaining to design and functioning of institutions to perform such tasks.

**IIF611 (2611) Economic Analysis of the Private Sector (Microeconomics).** Economic behavior of individual households and firms; how individual agents combine under different market structures including competitive markets, monopoly and monopsony. Theory of distribution and general equilibrium. Most topics receive both graphical and mathematical treatment.

**IIF612 (2612) Economic Analysis of Government.** Continuation of IIF611. In two parts: (1) Consideration of welfare implications of various forms of economic organization and rationale for government intervention in microeconomy. Theory underlying investment in government projects and environmental programs studies. (2) National economic constraints and aggregate behavior (macroeconomics) together with impact of government activity of these aggregates. Mathematical and graphical tools of analysis used.

**IIF613 (2613) Macroeconomic Theory.** National income accounting. Money and banking. Federal Reserve policy. Classical model of employment. Inflation. Keynesian model of income determination. Theories of consumption and investment. Fiscal policy. Foreign trade, Dynamic macromodels: accelerator-multiplier interaction. Harod-Domar growth model. Neoclassical growth models. Population growth. Regional development models.

**IIF617 (2617) Public Systems Analysis I.** Introduction to use of systems analysis in structuring public decision problems.

**IIF618 (2618) Public Systems Analysis II.** Covers use of mathematical modeling, simulation, optimization, and other systems analysis techniques to aid in management decisions in a broad class of environmental and public systems problems. Survey of applications in areas of transportation, water resources, governmental services, public health systems.

**IIF619 (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, water resources and material and energy wastes released into environment. Development of deterministic and stochastic models for steady-state and dynamic conditions.

**IIF620 (2620) Transportation Engineering.** Transportation systems analysis; traffic generation, distribution, 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.

**IIF621 (2621) Urban Transportation Planning I.** Urban transportation problems: roots, manifestations, implications; systems analysis approach to transportation; demand-and-supply side of transportation; urban transportation planning process; generation of alternatives and their evaluation; introduction to decision theory.

**IIF622 (2622) Multivariate Analysis Methods In Transportation.** 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.

**IIF623 (2623) Urban Transportation Planning II.**

Advanced study of conventional models of travel demand in transportation studies, including residential and nonresidential trip generation; Fratar, Gravity, 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. Propagation of errors in models.

**IIF624 (2624) Transportation Systems Analysis.**

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

**IIF640 (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.

**IIF641 (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.

**IIF643 (2643) Design and Planning of Mass Transportation.**

Study of mass transportation of past and present; innovative forms of mass and individual transportation in urban areas. Financing and organization of mass transportation: "free transit" vs. fares dilemma. Planning for mass transportation: special applications; implementation of plans; planning transportation in new towns.

**IIF644 (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.

**IIF747 (2647) Environmental Policy Analysis.**

Current research topics concerning application of economic and simulation techniques to definition and evaluation of public policy alternatives for managing air, land, water resources and material and energy wastes released into environment. Influence of technologic, economic, political uncertainty emphasized.

**IIF751 (2651) Environmental Quality Management for Agro-Ecosystems (Agricultural Engineering OAE 678).**

Application of systems analysis and mathematical ecology to problems in ecosystem management and environmental quality. Topics selected from: pest control, fertilizer usage, eutrophication, agricultural waste, soil and water conservation, public policy decisions affecting ecosystem management.

**IIF780 (2680) Environmental Control Workshop.**

Students interested in research topics dealing with control of 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 to be developed.

**IIF791 (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.

**IIF792 (2692) Public Systems Analysis Research.**

Investigation in depth of particular public systems problems.

**IIF793 (2693) Public Systems Planning and Analysis Colloquium.**

Lectures on various topics.

**IIF794, IIF795 (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.

**IIG351 (2751) Engineering Materials.**

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

**IIG610 (2710) Strength of Structure.**

Concepts of structural safety. Analysis of stress, strain, and strength in biaxial and triaxial loading. Theories of failure of ductile and brittle materials. Performance of structural materials and members under load: strain hardening, Bauschinger effect, residual stresses, effects of stress concentrations, creep. Design for brittle fracture and fatigue. Inelastic bending of beams. Limit design of steel and reinforced concrete structures. Critical discussion of recent research and current design codes.

**IIG611 (2711) Buckling: Elastic and Inelastic.**

Analysis of elastic and plastic stability. Determination of buckling loads and postbuckling 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 postbuckling behavior of plates, shear webs, cylindrical shells. Critical discussion of current design specifications.

**IIG612 (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, special transformations. Analysis techniques for tall buildings and other special problems.

**IIG613 (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, solids. Extension of element and system solution techniques to deal with problems in elastic stability, inelastic deformation, finite displacements, dynamic response, other special behavior mechanisms.

**IIG614 (2714) Structural Model Analysis and Experimental Methods.** Dimensional analysis and principles of similitude. Direct model analysis, including materials, fabrication, loading, instrumentation techniques. Basic techniques of experimental stress analysis. Confidence levels for model results. Laboratory projects in elastic behavior and ultimate strength of model structures.

**IIG615 (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 including design codes, structural random vibration.

**IIG616 (2716) Prestressed Concrete Structures.** Behavior, analysis, design of prestressed concrete structures; pretensioning, posttensioning, precast construction; beams, slabs, composite members, continuous beams and frames, tension and compression members; prestress losses, section efficiency, end-zone stresses, deflection analysis, cracking, partial prestressing.

**IIG617 (2717) Advanced Reinforced Concrete.** Behavior, analysis, design of reinforced concrete structures; strength, safety considerations, deflection analysis, crack control, limit analysis, yield line theory; flexure, shear, torsion, axial loads, slenderness effects; beams, columns, slabs, continuous frames, two-way systems, composite construction, deep beams, ground-supported slabs, shear walls, folded plates.

**IIG618 (2718) Behavior and Design of Metal Structures.** Contemporary methods for analyzing and designing metal structures. Behavior of structural elements and frames. Selected design applications from fields of steel plate structures, bridges, suspension systems, lightweight structures.

**IIG620 (2720) Shell Theory and Design.** Presents fundamentals of practical shell theory. Differential geometry of surfaces; membrane and bending theory of shells; analysis and design of cylindrical shells, polygonal domes, and paraboloids. Application to

reinforced concrete roofs and pressure vessels. Introduction to stability of shells.

**IIG622 (2722) Structural Design for Dynamic Loads.** Broad study of analysis, design, behavior of structures subjected to dynamic effects, emphasis on earthquake-resistant design. Vibration of simple systems; response spectra; numerical, energy, and matrix methods of analysis. Basic seismology. Analysis and design of structures for earthquakes, including inelastic effects. Modern design approaches.

**IIG630, IIG631 (2730,2731) Transportation Structures.** Treatment of structural design aspects of land, sea, air vehicles. Description of applicable design specifications, design environments, materials failure criteria, forms of construction, methods of structural analysis. Term paper required.

**IIG652 (2752) Advanced Plain Concrete.** Topics in field of concrete, such as history of cementing materials, air-entrainment, lightweight aggregates, petrography, durability, chemical reactions, properties of aggregates. Relationships between internal structure, physical properties, chemical properties, mechanical properties of interest to design and construction engineer.

**IIG653 (2753) Structure and Properties of Materials.** Internal structure of materials ranging from amorphous to crystalline state. Forces holding matter together versus forces causing deformation and failure. Correlation of internal structures of materials with their physical and mechanical properties. Applications to various engineering materials.

**IIG654 (2754) Low-Cost Housing Primarily for Developing Nations.** Multidisciplinary, involving faculty members from Architecture, Planning, Human Ecology. Students do intensive study usually in their own discipline for a term project; also introduced to problems and approaches of other disciplines. For engineers, primary purpose is to investigate technological aspects of the subject, while considering also other aspects that influence technological decisions, such as cultural and economic factors. Typical technological aspects are indigenous materials, structural systems, construction, maintenance, effects of physical environment. Coverage from agrarian-rural to industrial-urban.

**IIG690 (2790) Planning of Structural Systems.** Functional, structural, and other considerations in 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, shells. Erection, construction, stress control considerations. Computer structural analysis. Case studies with participation of practicing engineers.

**IIG693 (2793) Structural Engineering Seminar.**

Preparation, presentation, informal discussion of topics of current interest in field of structures.

**IIG694 (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 regular courses. Independent design or research projects may also be selected.

**IIG732 (2732) Optimum Structural Design.** Treats procedures to be applied in order to design minimum weight or minimum cost structures. Coverage encompasses simplified ideas such as fully-stressed design, classical minimization procedures, modern methods based on mathematical programming schemes.

**IIG757 (2757) Civil and Environmental Engineering Materials Project.** Individual projects or reading and study assignments involving civil engineering materials.

**IIG791 (2791) Design Project in Structural Engineering.** Comprehensive design projects by design teams. Formulation of alternate design proposals, including economics and planning, for given situation and complete design of best alternate. Determination of construction costs and preparation of sketches and drawings. Presentation of designs by oral and written reports.

**IIG792 (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.

**IIK502 (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. Case method used extensively.

**IIK510 (2010) Civil and Environmental Engineering Design Project I.** Design of major civil engineering project embodying several aspects of civil engineering. First term of two term sequence. Fall term: planning and part of preliminary design to be accomplished. Spring term: remainder of preliminary design and final design. Projects to be carried out by students working under direction of faculty project coordinator.

**IIK511 (2011) Civil and Environmental Engineering Design Project II.** Normally required for students in Master of Engineering (Civil) program. Continuation of IIK510 (2010).

**IIK520 (2020) Fall, IIK521 (2021) Spring. Professional Practice In Engineering.** Enrollment limited to candidates for professional Master of Engineering degrees. Introduces student to business, professional, managerial aspects of professional practice of engineering. Emphasis on legal, financial, social, ethical aspects. Other topics: personnel

management, labor relations, professional registration and organizations, engineering communications.

**IIK801 (2001) Thesis.** Gives student an opportunity to work out a special problem or to make an engineering investigation, to record results of work, to obtain academic credit for such work. Registration must be approved by professor in charge.

## The Classics

### Greek

#### III Modern Greek.

301 Greek Historians.

302 Greek Tragedy.

305 Aristophanes and Attic Prose.

306 Greek Melic, Elegiac, and Bucolic Poetry.

407 Graduate Reading Course. Reading in a major author or genre. Subject to be determined.

409-410 Advanced Greek Composition.

444 Greek Philosophy.

671-672 Advanced Greek Seminar. Topics to be announced.

701-702 Independent Study for Graduate Students.

### Latin

315 Roman Satire: Horace and Juvenal.

316 Roman Philosophical Writers.

317 Roman Historiography: Livy, Tacitus, Sallust.

318 Roman Elegy.

367-368 Medieval Latin Literature.

411 Cicero.

441-442 Advanced Latin Composition.

679-680 Advanced Latin Seminar. Topics to be announced.

751-752 Independent Study for Graduate Students.

### Classical Linguistics

Linguistics 631-632 Comparative Indo-European Linguistics.

425 Greek Dialects.

### Archaeology

220 Introduction to Classical Archaeology.

221 Archaeology of Classical Greece. Aegean archaeology from Neolithic period to eighth century B.C.

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

**History of Art 324 Architecture in the Greek and Roman World.**

**History of Art 424 Numismatics.**

**History 461 The Roman Revolution 146-44 B.C.**

**History 462 Early Imperial Rome, 44 B.C.-A.D. 70.**

**History 463 Classical Greece 510-404 B.C.**

**History 464 Classical Greece 404-338 B.C.**

**History 664-665 Seminar on Latin Paleography.**

## Communication Arts

**401 Communication Law.**

**403 Topics in Communication Theory.**

**404 Psychology of Communication.**

**420 Media Laboratory.**

**430 Visual Communication.**

**431 Art of Publication.**

**495 Independent Research.**

**501 Intercultural Communication.** Systematic survey of sociocultural and psychocultural obstacles to effective communication between cultures, subcultures, ethnic groups. Emphasis on analysis of culturally-related, nonverbal stimuli and their implications for intercultural and interethnic understanding. Examples drawn primarily from: (1) programs of change which cross cultural boundaries; (2) Peace Corps experience; (3) ethnolinguistic studies.

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

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

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

**526 Comparative Mass Media.** Comparative analysis of mass media systems in several selected national and sociocultural settings. Practice and behavior of media examined against ideological, legal, historical backdrop. Attempt made to

systematize common referents and some salient factors that lie outside of comparison.

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

**532 Methods of Communication Research.** Analysis of methods employed in communication research. Particular concern given to "rationale and use of" experimental, descriptive, historical-critical research methods.

**540 Special Problems in Communication.** Each semester discussion focuses on a topic or problem of special concern in the field of communication.

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

**550 Advanced Communication Seminar.** Designed to give graduate students opportunity to translate communication theory into practical, problem-oriented situations. Developed around special communication problems faced by different types of organizations, institutions, companies; case histories used to show how communication programs are organized and executed to help solve problems.

**590 Communication Teaching Laboratory.** Designed primarily for students who wish to gain experience in teaching communication courses. Students work with faculty member in development of course objectives, philosophy, planning and with actual instruction.

**595 Directed Graduate Study.**

## Comparative Literature

### Thematics

The following courses consider the selection and disposition of themes as an organic part of the artistic process by which content is metamorphosed into form; the way in which key figures as well as settings and events take on thematic aspects; problems involving archetypal origins, the continual recombination and ramification of traditional materials, artistic selection from available sources and adaptation to the dynamics of a particular form.

**416 Don Juan and Faust.** Authors include Tirso de Molina, Molière, Goethe, Shaw, and Mann.

**456 Utopias and Imaginary Voyages from the Renaissance to the Enlightenment.** Texts by More, Rabelais, Shakespeare, Swift, Voltaire, Sade.

**467 From Narcissus to Dionysos.** Texts by Hawthorne, Nerval, Pavese.

**479 Fiction and the Irrational.** Authors include Dostoevsky, Tolstoy, Flaubert, DeQuincey, Mann.

## Literary History

Understanding "history" in the broadest sense of the word that includes theory and stylistics, these courses study the system of literary norms, standards, and conventions, in progression from the individual work to the series and from the series to the period concept; the value of the deductive approach toward periodization founded on hypotheses vs. the inductive approach founded on facts; the concept of tradition, currents, crosscurrents, undercurrents; the idea of a canon.

**435 Ancient and Renaissance Literary Criticism.** Texts by Plato, Aristotle, Longinus, Scaliger, Castelvetro.

**436 Nature and Norms In Renaissance and Baroque Literature.** Authors include Castiglione, Montaigne, Shakespeare, Lope de Vega, Corneille.

**466 The Late Eighteenth Century.** Authors include Hume, Rousseau, Laclos, Sade, Wordsworth.

**499 Origins of the Avant-Garde.** Authors include Bely, Joyce, Woolf, Pasternak.

## Mode

This group of courses investigates problems relating to the organization of the values and assumptions operating in literary texts. Questions to be considered include: which textual parameters constitute a given text, what is its *Haltung* (and how is this concept, as well as that of mode, best defined and limited), relationships to the literary tradition (or textual codes), to the audience and its expectations, interpretative suggestions embedded in a text, e.g., allegorical, symbolic, or parodic dimensions.

**446 Allegory and Symbolism.** Authors include Dante, St. John of the Cross, Spenser, Goethe.

**463 The Picaresque Novel: El Lazarillo to Estebanillo Gonzalez.** Texts include *Simplicissimus*, *Gil Blas*, *Tom Jones*.

**493 Modern Variations of the Picaresque Novel.** Authors include Mann, Céline, Cary, Ellison, Bellow, Grass, Hawkes.

**693 Modern Parody.** Authors include Eliot, Beckett, Ionesco, Borges, Nabokov, Barth.

## Narrative

This group of courses will concentrate on the theory and practice of narrative writing. Special emphasis will be given to topics such as the following: form, setting, plot, characterization; fictionality and narrative transformations; ideology and historicity.

These problems will be explored in the contexts of contemporary and modern theories of narrative.

**468 Three Novelists: Rabelais, Cervantes, Sterne.**

**473 Autobiography as a Literary Form.** Authors include St. Augustine, Rousseau, Goethe.

**483 The Historical Novel.** Authors include Scott, Hugo, Manzoni, Tolstoy, Flaubert.

**488 Three Novelists: Stendhal, Dickens, Mann.**

**498 Dostoevsky, Mann, Glde.**

## Lyric

The following courses explore not only critical problems of analysis, interpretation, and evaluation in the lyric, but also theoretical problems involving prosody and form; rhetorical modes of voice and address; the concept of poetry as performance; the synchronic dimension of genesis and intentionality vs. the diachronic facticity of language and changing convention; the verbal texture of image, metaphor, symbol, and myth; and the historical evolution of style and world-view.

**412 Poetic Traditions of the Renaissance.** Texts from Tasso, Scève, Shakespeare.

**458 Petrarch, Ronsard, Donne**

**481 Baudelaire and Modernist Poetics.**

**491 Modernism In American and Russian Poetry.** Authors include Stevens, Mandelstam, Pound, Eliot.

## Drama

Comparative studies in drama investigate problems of mode and generic form (tragedy, comedy, melodrama, etc.); the nature of mimesis with special regard to myth and conventional archetypes; strategies of representation and stylization in plot, character, language, illusion; the structure of a text vs. the experience of a performance; the relationship of drama to other literary genres, e.g., poetry, fiction, as well as to other art forms, e.g., music, mime; the issue of periodization and style: Classicism, Realism, Surrealism, Expressionism.

**432 Greek and Roman Drama.** Authors include Aeschylus, Sophocles, Euripides, Aristophanes, Menander, Plautus, Terence, Seneca.

**472 Modern Dramatists.** Texts by Ibsen and Strindberg.

## Theory

Based primarily on an intensive study of theoretical writings, these courses will examine the implications of specific critical traditions and procedures. Areas of investigation will include: realism, theory of the novel, Marxism, formalism, structuralism.

**619 Myth and Literature.** Authors include Frye, Melville, Cassirer, Barth, Campbell, Levi-Strauss, Mann, Freud, Yeats.

**684 Theories of Interpretation: The Marxist Perspective.** Authors include Lukács, Brecht, Adorno, Benjamin, Gramsci, Goldmann, Marcuse, Macherey, Sartre.

**685 Theory of the Novel.** Authors include Scholes and Kellogg, Lämmert, Lukács, Goldmann.

**688 Literature and History.** Texts by Barthes, Mukarovsky, Jauss, Gadamer.

## Computer Science

**ICS314 (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. 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, compilers. Programming and debugging assembly language programs on a computer.

**ICS321-322 Introduction to Numerical Analysis.** Emphasis on algorithms appropriate for use with computers. Students solve representative problems on computer by programming these algorithms. Numerical methods for solving systems of linear equations and calculating eigenvalues and eigenvectors. Interpolation, differentiation, least squares; Chebyshev solution to discrete and continuous systems; integration. Numerical solution of ordinary and partial differential equations. Solution of nonlinear equations in several variables.

**ICS410 (409) Data Structures.** Data structures, relations between data elements, operations upon data structures. Lists, trees, graphs, other forms of data structures. List operations including linear lists, circular lists, arrays, orthogonal lists, multilinked structures. Binary tree representation, tree traversal, infinity lemma, tree enumeration. Lists and garbage collection. Dynamic storage allocation. Search and sorting techniques.

**ICS414 (404) Advanced Computer Programming.** Intended for students who wish to learn computer programming for eventual use in professional systems programming or advanced applications. Basic logical and physical structure of digital computers considered; applicability and limitations of this structure studied through many examples and exercises. Approach not theoretical, but an engineering one, in which techniques are emphasized. Students expected to participate in a large systems programming design and implementation effort.

**ICS435 (435) Information Organization and Retrieval.** Introduction to information retrieval. File organization and search algorithms. Statistical analysis and automatic classification of information.

Structural language analysis. Dictionary techniques. Interactive retrieval. Question and answering and data base retrieval. Evaluation of retrieval effectiveness.

**ICS481-482 (485-486) Introduction to Theory of Computing I-II.** Introduction to modern theory of computing: major results from automata theory, formal languages, effective computability, computational complexity, analysis of algorithms. Definition of abstract computing models including finite automata, push-down automata, Turing machines, and random access machines; their relation to formal languages and effective computability (regular sets, context-free languages, parsing algorithms, recursively enumerable sets, etc.); unsolvable problems related to these models, including the halting problem, equivalence and ambiguity problems for languages, Rice's theorem, etc. Quantitative problems in computing considered in terms of computational complexity theory, which includes computational complexity measures, properties of complexity classes, gap and speed-up theorems. Analysis of algorithms for random access machines with various measures of complexity; data structures such as heaps, priority queues, balance trees; application of depth first search to graph algorithms such as biconnectivity and strong connectivity; sorting, recursion, dynamic programming, introduction to reducibilities.

**ICS611 (411) Programming Languages.** Introduction to structure of programming languages. Specification of syntax and semantics. Properties of algorithmic list processing and string manipulation languages: basic data types and structures, operations on data, statement types, program structure. Macro languages and their implementation. Run-time representation of programs and data. Storage management techniques. Introduction to compiler construction.

**ICS612 (412) Translator Writing.** Discussion of models and techniques used in the design and implementation of assemblers, interpreters, and compilers. Topics: lexical analysis in translators, compilation of arithmetic expressions and simple statements, specifications of syntax, algorithms for syntactic analysis, code generation and optimization techniques, bootstrapping methods, compiler-compiler systems.

**ICS613 (413) Systems Programming and Operating Systems.** Organization and software components of modern operating systems. Batch processing systems. Loaders, input-output systems, interrupt handling. Descriptive schema for parallel processes; communication among parallel processes. Introduction to multiprogramming and multiprocessing systems. Addressing techniques, memory and instruction protection, procedure and data sharing; process scheduling, resource management; file organization, accessing, management. Time-sharing systems. Case studies in multiprogramming, multiprocessing, time-sharing. Job control languages and microprogramming. Projects

involving the design and implementation of systems program modules.

**ICS615 (415) Machine Organization.** Design and functional organization of digital computers. Boolean algebra, elements of logical design, computer components. Counters, shift registers, half and full adders, design of arithmetic units. Memory components, accessing and retrieval techniques, addressing structures, realization of indexing, indirect addressing. Control unit structure, instruction decoding, synchronous and asynchronous control. Input-output channels, buffering, auxiliary memory structure, interrupt structures. Overall system organization, reliability, system diagnostics, system simulation.

**ICS616 (416) Operations Research Models for Computer and Programming Systems.** Modeling and analysis of computer hardware and software systems. Some applications of 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 expected to program and analyze a model which can be applied to a problem of hardware or software design.

**ICS618 (517) Picture Processing.** Study of computer graphics and digital picture analysis. Topics: 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 transformations, graphics programming languages and systems.

**ICS621-622 (421-422) Numerical Analysis.** More thorough treatment of material of ICS321-322, at faster pace, and covering additional topics. Emphasis on algorithms appropriate for use with computers.

**ICS635 Special Topics in Information Retrieval.** Topics in theories of indexing and classification. Use of algebraic and probabilistic models for the analysis of storage organizations and retrieval processes.

**ICS641 (441) Mathematical Symbol Manipulation.** Arithmetic and algebraic algorithms and their implementation in a generalized computer system. Emphasis on symbolic rather than numeric techniques for solutions to problems. For each algorithm, computing times are derived and analyzed. Among topics: infinite precision integer arithmetic, modular arithmetic, operations on multivariate polynomials and rational functions, such as symbolic

integration and exact factorization over several fields, exact solution of linear systems.

**ICS681 (588) Theory of Algorithms and Computing I.** Advanced treatment of topics related to ICS482, including computational models for random access machines, measures of complexity, analysis of algorithms, arithmetic complexity, lower bounds on complexity of practical problems, reducibilities, and polynomial complete problems. Algorithms discussed include fast Fourier transform, integer and polynomial arithmetic, evaluation and interpolation, external problems in graph theory, planarity, triconnectivity.

**ICS682 (587) Theory of Algorithms and Computing II.** Advanced treatment of topics related to ICS481, such as axiomatic treatment of computability and computational complexity, including proofs from the axioms of certain theorems such as Rice's theorem, the speed-up theorems, hierarchy theorems. Also an abstract account of formal languages (AFL's, principal AFL's, etc.) and algorithmic languages (program schemata, subrecursive languages, etc.). At the instructor's discretion the course will include such topics as structure of the polynomial degrees, universal schemata classes, Grzegorzczuk hierarchy, equivalents of the LBA problem, classes of intractable problems, correctness of recursion rules, assignment of meaning to programs, natural unsolvable problems (word problems, Hilbert's 10th Problem, equivalence of schemata, etc.), investigations of time-space trade-off (Savitch languages, Cook's class, etc).

**ICS709 (591) Computer Science Graduate Seminar.** A weekly meeting for discussion and study of important topics in the field.

**ICS712 (487) Theoretical Aspects of Compiler Construction.** Formal methods of syntactic analysis, including precedence, bounded context, and LR techniques. General parsing methods and their time-space complexity. Noncanonical parsing techniques. Two-level grammars. Formal methods of object code optimization. Methods of formal specification of semantics of programming languages.

**ICS719 (611) Seminar In Programming.**

**ICS721 (521) Solutions of Nonlinear Equations and Nonlinear Optimization Problems.** Emphasis on rigorous analysis of practical numerical algorithms for nonlinear problems. Sample topics are nonlinear functional analysis, constrained and unconstrained minimization, computationally convenient modifications of Newton's method, including quasi-Newton and penalty function methods and nonlinear least squares.

**ICS723 (523) Numerical Solution of Ordinary Differential Equations and Integral Equations.** Topics: solution of  $n$ th order nonlinear initial value problems and boundary value problems; single step methods; predictor-corrector techniques; stability, accuracy, precision of methods; eigenvalue problems; solution of integral equations having

constant or variable limits: finite difference and iterative methods; singular and nonlinear integral equations.

**ICS725 (525) Numerical Solution of Partial Differential Equations.** General classification; 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.

**ICS727 (527) Introduction to Approximation Theory.** Study of best approximations to functions. Topics: algorithms for best uniform and  $L^1$  approximation by polynomials and rational functions, Padé approximation and continued fractions, Kharshiladze-Lozinski theorems, construction of best routines for evaluation of functions.

**ICS729 (621) Seminar in Numerical Analysis.**

**ICS739 (635) Seminar in Information Organization and Retrieval.**

**ICS781 (488) Advanced Theory of Computing.** At instructor's discretion, advanced results in automata theory, computability, computational complexity. Topics may include noneffectiveness of speed-up, honest naming theorem for complexity classes, definition of operator complexity and reducibility classes, comparison of the power of programming languages, relationship between algorithmic languages and formal theories, equivalence algorithms for multitape finite automata, computational complexity of decision problems (Presburger, Tarski's algorithms, etc.), equivalents of the LBA problem (pebble automata and auxiliary pushdown automata).

**ICS782 (589) Advanced Topics In Algorithms.** At instructor's discretion, advanced results in analysis of algorithms. Topics may include detailed analysis of complex algorithms, relationships between time and tape complexities, polynomial complete problems and reducibilities, complexity of decision problems, recent results from the literature.

**ICS789 (681) Seminar in Automata Theory.**

**ICS790 (590) Special Investigations in Computer Science.** Independent research.

**ICS890 (590) Special Investigations in Computer Science.** Master's degree research.

**ICS990 (590) Special Investigations in Computer Science.** Doctoral research.

## Consumer Economics and Housing

**320 Economics of Consumption.** Survey of economics of consumption. Major topics: history of empirical studies of consumer behavior, economic theory of consumer behavior, work-leisure choice

and its relation to plans for income maintenance, influences and constraints affecting rationality of consumer choice, past trends and present levels of income and consumption in U.S., intercountry comparisons of consumption, development of standard budgets and their use, predicted future patterns of consumption.

**333 Principles of Marketing.** Study of marketing functions, institutions, policies, practices with emphasis on their role in creating consumer satisfaction. Current problems identified for in-depth study. Field trip to New York City to study selected marketing operations arranged when feasible.

**341 Fundamentals of Housing Economics.** Designed to give student a basic understanding of structure and operation of housing market. Economic determinants of housing supply and demand related to (1) levels of housing consumption and housing standards, (2) composition of housing inventory, (3) levels of and fluctuations in housing production. Influence on housing market of institutional forces, including building codes, zoning, finance, taxation also examined.

**349 Provision of Housing in the United States.** Analysis of impact of social and technological change upon structure, operations, performance of various housing submarkets and their productive mechanisms. Particular attention to governmental programs designed to alter performance in furthering current and emergent societal goals.

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

**413 Exceptional Families: An Ecological Approach to Their Resource Management.** Examination of special managerial problems faced by families with exceptional imbalances in different resources. Analysis of techniques of compensating for resource limitations in families in poverty, with health handicaps, with young mothers in labor force, one-parent families, student couples and retired couples. Students expected to work independently in assembling and evaluating materials relevant to resource management. Case studies. Field trips. Suggested for students preparing to work with families in health and rehabilitation programs, social work, geriatrics, adult education programs, financial counseling. Field experiences build on student's specialization within Human Ecology.

**425 Economics of Recreation and Leisure.**

Focuses on recreational use of leisure time. Framework of analysis employs a view of recreational activity as a consumer good resulting from an economic decision by individual or household as to allocation of scarce resources—time and money. Contributions of other social sciences examined, and empirical studies reviewed in terms of alternative recreation theories.

**443 The Social Effects of the Housing Environment.**

Seminar dealing with extent to which social ends may be accomplished through manipulation of housing environment. Physical and social deterministic viewpoints considered. Approach based on critical analysis of research in the field.

**465 Consumer and the Law.** Emphasis on work of federal agencies and on court decisions as these affect consumers in the market. Topics: liability for injury from consumer products; laws covering safety of drugs, labeling, advertising; consumer problems arising from ignorance and poverty.

**472 Community Decision Making.** Designed primarily for students interested in political aspects of public policy questions at local community level.

Concentration on investigation of relationships between individuals and the political system. Consideration of political participation, decision-making processes and structure, community conflict, community change. Concurrent participation in community activities desirable but not required.

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

**485 Public and Private Decision Making.** Formal models dealing with operations of coalitions within bureaucracies and electorates. Effects which organizational structure and voting strategies have upon the decision-making process. Topics complementary to subjects dealt with in courses in welfare economics.

**600 Special Problems for Graduate Students.**

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

**619 Seminar in Family Decision Making.** Decision-making processes in relation to family goals and goal implementation. Situational factors that restrict alternatives and resources that expand alternatives and criteria used in selection of alternatives. Emphasis on total decision event.

**620 Consumption Theory.** Presents major developments in micro- and macroeconomic theory of consumption. Topics: theory of utility and

preference, substitution and income effects, absolute and relative income hypotheses, consumption implications of alternate growth models.

**621 Explorations in Consumer Economics.**

Students with guidance from instructor undertake an independent investigation in a broad area of consumer economics such as: income maintenance, consumer protection, intercountry consumption indices, income distribution, theoretical advances in consumption theory. Effort oriented toward and evaluation based on student's final presentation, which may take one of following modes: departmental seminar, learning module. Guest hours to be arranged. S-U grades optional.

**630 Family Financial Management.** Study of developments in family financial management field with emphasis on role of consultant. Each student expected to work with families on money management problems.

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

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

**645 International Low-Cost Housing.** Aspects of low-cost housing involving engineering technology, architecture, physical planning, economics, sociology. Students from these fields, and related fields, meet for common lectures and discussion periods led by multidisciplinary faculty group. Group coverage of topics broad in hope that all students understand all topics. Special effort made to present various topics so that engineers, architects, economists, sociologists may understand each other's problems and be able to communicate and work together. Emphasis on developing, nonindustrial countries, although modern principles included, since they may apply to all countries. Should be of primary interest to students from developing countries and those interested in basic housing problems.

**648 The Social Demography of Housing.** The purpose is to develop skills in social and demographic analysis of housing. Dynamic relationships between size and composition of population of households and amount and quality of the housing stock analyzed in light of social norms and values relative to housing.

**649 Production of Housing.** Examination of system of producing shelter in its structure, major processes. Decision making within existing institutional constraints. Description and evaluation of major

subsystems. Special attention devoted to production of housing in conjunction with a number of special-purpose governmental programs.

**671 Intergovernmental Relations and Local Community Change.** Description and analysis of the intergovernmental system with special attention to public problem solving and community change at local level. Impact of local political systems on effectiveness of state and federal programs. Ways, if any, in which state and federal programs alter local political systems.

**680 Applied Welfare Economics—Policy Issues.** Topics vary from year to year. Evaluation of economic impact of various policies in conjunction with efficiency of existing institutions. Policy issues covered relate to education (effects of automation, etc.), health, environmental problems (urban development, transportation, etc.). Interrelationship of policy and planning with larger economic-sociopolitical framework.

**697 Seminar.** Orients students to graduate work in the Field. Keeps students and faculty abreast of new developments and research findings; acquaints them with subject matter in related areas. Provides opportunity to examine and discuss problems of the Field.

**720 Economics of Consumption.** Review of theories of consumption function and of recent literature on family consumption, including demand elasticities; family saving and investment, including investment in human capital; economic determinants of participation of women in labor force. Particular attention paid to analytical techniques used on empirical data and problems involved in research in this Field.

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

**743 Readings in Housing.**

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

**899 Master's Thesis and Research.**

**999 Doctoral Thesis and Research.**

## Design and Environmental Analysis

**319 The Child-Oriented Environment.** Application of user-feedback methodologies to analysis of environments designed for children, incorporating both user response techniques and observational techniques. Emphasis on student-directed research projects.

**330 Household Equipment Principles.** Principles of operation of appliances for food preparation and preservation, maintenance of apparel and furnishings. Evaluation of characteristics and features in relation to their intended function and cost.

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

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

**343 Design: Introductory Textile Printing.** Studio course exploring the print as a design form.

**344 Intermediate Textile Design: Silk-Screen Printing.** Studio course emphasizing the development of professional silk screen printing skills and techniques.

**346 Advanced Textile Design.** Advanced design problems in textile printing posed and solved in professional fashion.

**349 Graphic Design.** Fundamentals of lettering, typography, layout, presentation techniques, printing processes. Graphics applied to product, interior, exhibit design, packaging, informational systems.

**350 Environmental Analysis: Person, Activity, Space.** Study of ways in which physical aspects of 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 near environment, those aspects of consumer information programs concerned with choice of products in relation to optimal level of effort and selected characteristics of activities.

**353 Historic Design III: Contemporary Design.** Historical study of emergence and development of contemporary design, 1885 to present. Examination of social, economic, technical, style forces which shape design forms of present.

**360 Design IV: Design Procedures.** Study of fundamental principles and procedures linking professional design fields. Problems in interior, industrial, apparel, graphic design realized in final two- or three-dimensional form.

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

**365 Interior Space Planning I.** Planning of interior architecture with emphasis on fundamentals of structure, lighting, circulation requirements, equipment selection, color, particularly user-need determination.

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

**375 Residential Environments: The Behavioral Basis for Design Decisions.** Major trends in housing research, emphasizing user-evaluation of architectural effectiveness, translated into operating architectural vocabulary needed to make physical design decisions.

**430 The Textile and Apparel Industries.** Critical review of structure and economic aspects of textile and apparel industries, followed by field experience in textile regions of the South and/or New York.

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

**438 Textiles In Fashion and Function.** Critical review of innovations in consumer textiles from standpoints of researcher, designer, producer, retailer, government, consumer. Complex interrelationships of pollution control, product safety, consumer satisfaction. Specifications, labels, and other means of communication among groups and individuals concerned.

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

**445 Apparel Design IV: Experimental Processes.** Studio course emphasizing the functional aspects of clothing. Laboratory problems relate needs and function of the body, structural properties of materials, flat pattern forms.

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

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

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

**463 Product Design I.** Development and analysis of a series of products for use in either homes or institutional settings, with emphasis on design as related to materials and production methods.

**464 Product Design II.** Analysis and development, from sketch stage to operating prototype, of either a single product or an interrelated series of products selected by student.

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

**466 Interior Space Planning II.** Designing of public interior environments with emphasis on spatial organization, acoustical control, material specifications, budget constraints.

**467 Interior Space Planning III.** Advanced exploration of a specific complex interior-environment package.

**600 Special Problems for Graduate Students.**

**620 Instrumental Analysis.** Introduction to theoretical and practical aspects of instrumentation including spectroscopy, chromatography, electrophoresis, other selected techniques.

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

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

**636 Advanced Textile Chemistry.** Study of new developments in textile chemistry including new polymers, finishes, and dyes, biodegradability, environmental effects on textile materials.

**638 Textiles in the Near Environment.** Consideration of environmental agencies influencing the behavior of textile materials: effects of mechanical wear, soiling, heat, radiation, weathering, aging.

**650 Person-Activity-Environment Relationships.** Human requirements, capabilities, and limitations studied with reference to design and organization of consumer products, interior spaces, work. Literature concerns ergonomic or human-factors data and description and measurement of work and other activities.

**651 Environmental Awareness.** Study of person-environment relations exploring interaction between social science and design and problem-solving roles of the individual and science within an ecological framework.

**655 Social Psychology of the Near Environment.** Impact of near environment on our behavior as social animals. Frameworks developed for analyzing our social behavior in various settings where we function.

**899 Master's Thesis and Research.**

## Development Sociology

**405 Organization Dynamics.** Study of methods and techniques by which organization consultants, officers, group members, administrators may increase effectiveness of organizations. Five categories of organization problems considered: (1) program problems, (2) leadership problems, (3) membership problems, (4) problems related to meetings, (5) organizational and public relations problems.

Organization theories presented in relation to their uses in analysis, prediction, diagnosis, and in designing programs to bring about organizational changes. First hour is lecture-discussion period; second hour is group skills, group process, group sensitivity laboratory.

**411 Community and Regional Development and Planned Change.** Various strategies of development and planned change explored. Programs, organizations, agencies, and institutions operating in communities and regions that address themselves to various development strategies. Two major emphases: (1) structural-functional roles and processes of organizations, agencies, institutions as they implement programs of change and development in communities and regions, (2) roles of professionals and change agents representing and operationalizing development units.

**412 Rural Social Systems.** Rural sector of American society. Theory, methods, findings of sociology and related social sciences presented by relating them to such contemporary issues as technological change and agricultural adjustment, rural to urban migration, allocation of goods and services, rural poverty, migrant labor, directed social change. Allocation of goods, services, power, prestige (patterns of equality-inequality) emphasized.

**420 Social Change in Community and Regions.** General review of theory, empirical studies, and policy prescriptions as applied to communities and regions, especially those in less developed countries. Macrodiffusionist perspective, Weberian tradition, central place theory, neo-Marxist economic structuralism compared. Their capacity to interpret social change in subnational units assessed with respect to role of technology, innovation, growth, decline, stagnation, dualism, social movements, conflict.

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

**436 Social Movements and the Sociology of Confrontation.** Seminar designed to provide opportunity for maximum student participation. Students, under faculty supervision, plan and organize the course. Interaction between available theories of collective behavior and selected comprehensive case studies. Theories of Blumer, Heberle, the Langs, Smelser, Toch, Turner, Young, and others used to help understand selected cases from a wide range of social movements such as Black Power movement, national farm organizations, various student movements.

**437 Differential Life Styles of the Aging.** Life styles of aging analyzed and evaluated from standpoint of disengagement theory, age segregation versus age

integration, retirement process. Study of research literature, some interaction with older persons in a variety of living arrangements, field trips provide students with basis for proposing innovative life styles as well as modifications in present arrangements.

**440 Introduction to Computer Uses in Data Analysis.** Introductory computing open to all students with interests in analyzing data. Topics: preparation and description of data; preparation and running of computer programs using the FORTRAN language; computer attributes and applications; library programs and associated facilities.

**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 viewed relative to productive, allocative, and staffing processes of society, as they affect various occupational categories, communities of different size, institutions primarily responsible for maintaining social order.

**456 Rural Development and Cultural Change.** Analysis of planned social change programs in predominantly agricultural societies. Problems of administration, socioeconomic development, introduction of new practices and techniques. Data on resettlement, community development, irrigation, social problems caused by new high-yielding grain varieties. Designed for students concerned with professional or technical work in transitional social systems.

**498 Community Structure and Aging.** Study of model for conceptualizing and measuring dimensions along which communities vary. Implications of model for social planning and public policy examined in context of community's aging population. Special attention to community programs, facilities, services for the aging and to impact of community environment on behavior and attitudes of the aging.

**501 Crossdisciplinary Seminar: Perspectives on Development.**

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

**511 Introduction to Urban and Regional Theory.** Interdisciplinary course focused on social, political, economic aspects of regional America. Viewed from perspective of demography, ecology, social organization, planning, emergence of a new society form and its implications for contemporary America considered.

**514-515 Research Design I-II.** Two-semester sequence in graduate-level research methods dealing with data-gathering problems (either course may be taken individually). Sampling frames. Some discussion of statistical analysis in both.

Research Design I(514). Problems of measurement. Emphasis on design of measuring instruments, problems of reliability and validity. Some common forms of measuring instruments discussed: paired

comparison, Likert and Guttman scales and some discussion of multidimensional techniques. Factor analysis included.

Research Design II(515). Problems of research design and legitimacy of inferences discussed. Students expected to use actual data and thus familiarize themselves with data handling and processing. Nonexperimental designs, regression analysis, analysis of variance, analysis of covariance, causal models. Classic piece of sociological research is one source of illustration and laboratory exercises.

#### **516 Macrostructural Research Methods.**

Comparative study of large social systems presented as new research style that is especially appropriate to research in and on developing countries. Field technique of macrosurveys and the uses of available data such as national social accounting, documents, ethnographic reports, aerial photographs emphasized. Trend studies; assumptions of macrostructural analysis; rapid, low-cost research procedures; mechanics of data archives.

#### **517 Macrosociological Description of a Single Country.**

Designed for students who want to learn how to make a sociological description of a whole country. Each student guided throughout term in constructing description of a country of his own choice. Topics: country's place in various international hierarchies; identification of political units, bureaucracies, corporations, development projects; changes in status of ethnic groups and political parties; organization of agriculture, population movements, etc. Simple descriptive materials from a variety of mostly less developed countries, but including states of U.S. Standard categories and indices and a recently developed system of macrosocial accounting. Alternates with R.S. 516.

#### **522 Social Power and Community Change.**

Sociological approach to power as an aspect of community life. Methodological and theoretical approaches of recent community power studies analyzed. Representativeness, responsiveness, output of decision-making structures and effectiveness of change strategies considered.

#### **528 Applications of Sociology to Development Programs.**

Consideration of problems of implementing change strategies at national, regional, institutional levels, especially as they relate to rural development. Focuses on institutional obstacles to increasing the amount of wealth generated and retained within a system and existing patterns of wealth distribution and how these can be changed through developmental programs and processes. Examination of the emerging literature on societal or developmental change as contrasted to social or evolutionary change. Consideration of the different contexts within which developmental change occurs and power balances between different factors in international and national systems.

**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.**

**614 Factor Analysis and Multidimensional Scaling.** Topics: philosophy of factor analysis, factor analysis models, factoring design, factoring techniques, an overview of multidimensional scaling and a comparison with factor analysis models, an in-depth investigation of Smallest Space Analysis, MDSCAL and other multidimensional scaling techniques. Student must have some previous coursework in scaling and statistics. Matrix algebra is integral part of these procedures, some class time plus extra sessions devoted to this topic. Student is expected to complete several lab assignments using the techniques.

**624 Seminar: Macro Systems Theory.**

**630 Seminar: Contemporary Social Theory I.**

**631 Seminar: Contemporary Social Theory II.**

## Ecology and Evolutionary Biology

All courses carry Biological Sciences numbers unless otherwise indicated.

**261 Introductory Ecology.** Basic grounding in principles of ecology as a fundamental science. (Students concentrating in this Field must take Biological Sciences 361 instead of this course.) Students may not have credit for both 261 and 361. Topics include growth and limitation of populations, interactions between populations, structure of communities, flow of energy and cycling of materials in ecosystems. Ecological effects of human overpopulation and its attendant problems.

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

**361 General Ecology.** Principles concerning interactions between organisms and their environment. Influence of competition, social behavior, predation, 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 stressed throughout and attention given to conflicting ecological hypotheses.

**364 Introduction to Marine Science.** This special course offered at Shoals Marine Laboratory of Cornell University, Isles of Shoals, off Portsmouth, New Hampshire, 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 Taxonomy of Vascular Plants.** Introduction to evolution and classification of vascular plants, with attention to principles, methods of identification, literature. In first part of term, trips are held in laboratory periods.

**373 The Vertebrates.** Introduction to evolution, classification, comparative anatomy, life history, behavior of vertebrate animals. Laboratory dissection, experimentation, demonstration concerned with structure, classification, systematics, biology of species, studies of selected aspects of vertebrate life.

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

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

**463 Limnology, Laboratory.** Laboratories devoted to both field studies and experiments on model ecosystems.

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

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

**467 Chemical Ecology.** Ecological and evolutionary significance of chemical interactions of 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; microorganisms. Choice of adaptive strategy in relation to energy flow. Practical applications of chemical ecology.

**468 Species Distribution and Abundance.**

Advanced course emphasizing unifying principles of ecology, biogeography, population biology. Topics: 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; 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.** Introduction to study of fishes: their structure, classification, evolution, distribution, ecology, physiology, behavior. Laboratory studies on structure, identification, classification, nomenclature. Field studies of local species.

**470 Ichthyology.** Lectures on advanced aspects of biology of fishes including systematics, ecology, life history, literature. Laboratory studies of orders, major families, principle genera, and of systematic procedures. Field studies of ecology and life history of local species.

**471 Mammalogy, Lectures.** Lectures on evolution, classification, distribution and adaptations, both physiological and morphological, of mammals.

**472 Mammalogy, Laboratory.** Laboratory and field work on ecology, behavior, physiology, and taxonomy of recent mammals, with emphasis on North American fauna.

**473 Ornithology.** Lectures cover various aspects of biology of birds, including anatomy, physiology, classification, evolution, migration and orientation, behavior, ecology, and distribution, and are fully integrated with laboratory studies. Laboratory includes studies of external and internal morphology, pterylosis, molts and plumages, specimen identification of birds of New York, families of birds of the world. Several demonstration periods emphasize hybridization, evolution, adaptive radiation, mimicry, geographic variation. Occasional field trips and special projects included.

**474 Herpetology.** Lectures on evolution, distribution, adaptations of reptiles and amphibians. Emphasis on ecology, behavior, physiology. Laboratory and field work on systematics, ecology, behavior, physiology. Several required evening field trips and at least one Saturday field project. Some laboratory work requires measurements to be made at intervals during the day and evening. Each laboratory section limited to twelve students.

**475 Herpetology Lectures.** Lecture portion of 474.

**476 Organic Evolution.** Lectures and class discussions on organic evolution, with primary emphasis on mechanisms of animal speciation and

adaptation. Begins with a few lectures on taxonomic methodology.

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

**512 Comparative Physiology.** Comparison of principal physiological functions of vertebrates and invertebrates, with emphasis on adaptation to different environments.

**513 Comparative Physiology Laboratory.** Introduction to comparative physiological techniques and their application to original research projects.

**561 Quantitative Ecology.** Quantitative course on selected ecological topics for advanced undergraduates and students. Topics: origin and interpretation of habitat differences, tolerance and response physiology, population dynamics, construction and uses of life tables, spatial distribution patterns, approaches to the quantitative analysis of biotic communities.

**562 Ecology of Pest Management.** Ecology of pest management for development of safe, economical population control measures. "Systems Approach" to management of pests (insects, algae, weeds, animal and plant pathogens, birds, mammals) emphasized.

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

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

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

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

**573 Special Topics In Lower Vertebrates.** Detailed consideration of selected topics in comparative physiology, behavior, ecology, systematics. Topics vary from year to year.

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

**661 Seminar in Population and Community Ecology.** Topics to be announced each semester.

**663 Seminar In Evolution and Ecology of Vascular Plants.** Consideration of primary problems concerned with classification, evolution, environmental relationships of vascular plants.

**665 Autecology.** Consideration of 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 properties and dynamics of populations. Emphasis on theories of population structure, genetics, dynamics, regulation. Discussion of experimental approaches to analyses of natural populations.

**667 Community Ecology.** Structure and dynamics of natural communities; patterning and sampling problems, species-diversity, gradient relations, succession, classification. Comparative aspects of terrestrial, marine, freshwater communities stressed.

**668 Ecosystems.** Analysis of ecosystems in terms of energy flow, materials circulation, model systems; biogeochemistry, pollution, human ecology. Emphasis on functional properties of ecosystems considered from simple systems to biosphere as a whole.

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

**Agronomy 406 Soil Microbiology.** Study of major groups of soil microorganisms, their ecological interrelationships, biochemical functions of soil organisms.

**Agronomy 407 Soil Microbiology, Laboratory.** Laboratory exercises concerned with ecology and biochemical activities of soil microorganisms.

See also Agronomy 404, 606; Entomology 331, 351, 531, 532, 533, 534, 551, 553, 672; Microbiology 492; Natural Resources 439; Neurobiology and Behavior 421, 523, 622; Plant Pathology 309.

## Economics

**509 The Theory of Household and the Firm.** First semester in two-semester sequence in microeconomic theory. Concerns decision processes of individual firms and individual consumers. Individual and aggregate demand and supply relations derived. Other topics discussed include uncertainty and capital theory.

**510 The Theory of Markets and General Equilibrium.** Functioning of markets for goods including cases of pure competition, monopoly, duopoly and monopolistic competition. Markets for factors of production: labor, land, capital,

entrepreneurship. Theory of general equilibrium and welfare economics. Pareto optimality. Theory of second best. Nonmarket decision making.

**511 Microeconomic Theory.** One-semester introduction to microeconomic theory. Topics: theories of consumer behavior, the firm, markets; general equilibrium, income distribution, welfare economics.

**512 Macroeconomic Theory.** Less extensive treatment of many topics in economics than in 513, 514—consumption, investment, demand for money, static income determination, cyclical behavior, inflation.

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

**514 Macroeconomic Theory: Dynamic Models, Growth and Inflation.** Continuation of 513. Economic fluctuations, inflation, theories of growth and optimal growth and "short-run growth" models.

**517 Intermediate Mathematical Economics.** No prior acquaintance with mathematical topics covered required. Economic subjects: economic models, static or equilibrium analysis, comparative-static analysis, optimization of objective functions subject to constraints, production functions. Mathematical topics: 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: 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: integration, differential equations, simultaneous equation models, linear programming, game theory.

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

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

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

**523-524 American Economic History.** Concentration on three lines of investigation: use of economic and statistical analysis as an aid in

answering historical questions; use of historical experience in determining validity of aspects of economic theory; extent to which historical economic experience is useful in resolving current economic problems. Problems selected from period 1800-1939.

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

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

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

**536 Collective Choice: Theory and Application.** Modeling of political behavior by economic techniques. Theory of voting. Political models applied to economic problems as allocation of public goods and distribution of income.

**551 Industrial Organization.** Analysis of prevalence and effectiveness of competition in American economy centering on structure, conduct, performance of American industry. Structural characteristics discussed include concentration, economies of scale, product differentiation, barriers to entry. Among numerous aspects of business behavior examined: merger decisions, pricing, advertising, technological innovation policies. A number of case studies of American industries and firms read, with emphasis on relating theories of monopoly, oligopoly, competition to histories of specific firms and industries.

**552 Public Regulation of Business.** Continuation of Economics 551, concentrating mainly on public policies of enforcing, supplementing, or replacing competition, with specific studies of selected industries and recent legal cases.

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

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

**565 Economic Problems of Latin America.** Survey of current economic policies and performance in

Latin America, with special attention to inflation, balance of payments, economic integration, plan implication, income distribution.

**566 Introduction to the Japanese Economy.** Japan as a case study of modernization and industrialization in a non-Western society. Sources of Japanese growth traced from Meiji period to present with special emphasis on postwar economy. Topics: capital formation, role of government, industrial organization and zaibatsu system, foreign trade and investment, labor markets and human resources. Also, social, political, environmental issues raised by recent rapid development.

**567 Comparative Economic Systems: Soviet Union and Europe.** Discussion of rationality and feasibility of economic planning (von Mises, Hayek, Lange). Examination of various approaches to planning, including discussion of 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 planned systems.

**568 Contemporary Brazil.** Study of style of development in economy, polity, society followed by contemporary Brazil, along with analysis of contradictions that led to military coup of 1964 and its aftermath; some comparisons with other Latin American countries made. Assigned readings in English.

**571 Economic Development and Sociopolitical Modernization.** Effort to view development of low-income countries as both economic and noneconomic process. Relevance and limitations of conventional economic analysis explored, together with problems of bringing about institutional change. The role of established power in preserving basic institutions and to emergence of opposed power systems as necessary to their modification.

**572 Processes of Economic Growth and Development.** Consideration of various contributions by economists and others to an understanding of how societies undergo economic growth and institutional change. Developing countries are 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 explored.

**575 Economics of Poverty.** Examination of poverty in the U.S. today (urban and rural) in relation to functioning of 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".

**578 Economics, Population, and Development.** Introduction to economic aspects of population and interaction between population change and economic change. Economic views of fertility, mortality, migration and to impact of population

growth on economic growth, development, modernization.

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

**611 Advanced Microeconomic Theory.** General subject of this seminar closely related to comparative economic systems. Relationship between information structures, economic environments, economic systems. Principal research in this field is work of Hurwicz, Reiter, Ledyard, Marschak, Radner.

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

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

**617-618 Mathematical Economics.** Rigorous approach to problem of general equilibrium analysis presented. Following subjects treated mathematically: demand theory, stability of equilibrium, pareto optimality, existence of equilibrium, 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, matrix algebra. Classical linear regression model discussed and its several assumptions weakened in turn. Discussion of systems of equations, their properties, the methods of estimating such systems. At the end of 620, an overview is given of other econometric techniques such as factor analysis and spectral analysis. Emphasis on theoretical framework of econometrics, although some applications discussed.

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

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

**626 Methods in Economic History.** Methods course concerned with causal explanation and model building in history, economics, cliometrics alternatively called the new economic history.

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

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

**638 Public Finance: Local Government and Urban Problems.** Rationale for government activity in urban areas examined. Theoretical models of local government and structural problems arising from multiple and layered jurisdictions, inflation and growth studied. Housing, transportation, environmental, poverty, crime, discrimination problems and proposed solutions analyzed within this framework with emphasis on distributional and efficiency aspects.

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

**648 Issues in Latin America.** Each year a theme is chosen that highlights a current issue in social sciences related to analysis of socioeconomic development in Latin America.

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

**652 Industrial Organization and Regulation.** Discussion of goals of a free-enterprise economy; followed by examination of role of government in achieving those goals. Various tools of government control such as antitrust laws, regulation, public ownership examined in some depth and evaluated. Conditions of market failure, in a variety of market situations as in education, conservation, health discussed in 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, transfer mechanism, theory of gains from trade, trade under imperfect market conditions, trade and economic growth, related subjects.

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

**666 Special Topics in International Finance.** Intensive examination of theory of forward exchange and short-term capital movements, Euro-dollar market, theory of internal-external equilibrium, other topics.

**670 Seminar: Economic Demography and Development (Sociology 670).** Economic aspects of population dynamics with particular emphasis on interaction between population change and economic development. Topics: role of economic factors in fertility, mortality, migration; place of population growth and migration in development and modernization process; policy implications and rapid vs. slow or zero population growth for economic development.

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

**674 Economic Systems.** Periods covered are N.E.P., centralized integral planning, current K.B. reforms. Application of the Soviet model to East European countries considered together with current reform movements.

**675 Growth and Development.** Theory of economic development. Descriptive and normative models of economic growth discussed.

**676 The Economy of China.**

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

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

**679 Theory of Economic Development.**

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

**682 Economics of Participation and Labor-Managed Systems: Economic and Planning.** Uses theory developed in 681. Role and mechanics of economic policy and planning in participatory economy. Growth potential of that economy analyzed in context of modern theory of economic growth.

**684 Seminar in Economic Theory.** Designed to train graduate students in conducting research work on advanced topics of economic theory or application of advanced theories to applied fields. Topics and content may change from year to year.

## Education

The following courses are taught in the Department of Education, New York State College of Agriculture and Life Sciences.

**401 Our Physical Environment.** Study of commonplace phenomena and substances in our physical environment, and their use in demonstrating basic scientific principles. Frequent field trips and firsthand examination used in studying air, water, soil, light, sound, and some elementary mechanical and electrical devices. Emphasis on physical environment as an aid to teaching physical sciences in public schools.

**402 Literature in Conservation and Environmental Education.** Examination of books, periodicals, reports dealing with historical and present aspects of environmental quality and education. Students are involved in planning and offering the lectures, discussions, 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. Working knowledge of biology and ecology assumed.

**404-405 Field Natural History.** Devoted to studies of Northeastern plants and animals, their biology, ecology, and use in environmental education programs of interpretive centers, schools, and field biology courses. Man's impact on plant and animal communities stressed.

**407 Teaching of Elementary School Science.** Content and methods of elementary school science, with field work and laboratory emphasis on modern and experimental curricula. Includes class observation and experimentation. Designed particularly for those preparing to teach or supervise elementary school science.

**408 Methods of Teaching Science in Secondary Schools.** Consideration of current methodology, newly developed curricula, materials for teaching science in secondary schools. Attention given to the aims and goals of science instruction in relation to classroom techniques.

**409 Practice in Teaching Science in Secondary Schools.** Supervised practice in teaching science in secondary schools.

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

**417 Psychology of Adolescence.** Survey of nature of adolescent growth and development, with emphasis on some causal factors pertaining to adolescent behavior.

**432 Methods, Materials, and Directed Practice in Teaching Agriculture in the Secondary School.** Directed participation in off-campus centers in specific and related problems of teaching agriculture

at junior and senior high school levels, which includes adjustment in the school and community; evaluation of area resources, materials of instruction, and school facilities; organization and development of local courses of study; launching and directing work experience programs; planning for and teaching all-day classes; advising occupational youth organizations; other problems relating to development of a balanced program.

**433 Special Problems in Agricultural Education.** Provides students an opportunity to study individually or as a group, selected problems in agricultural education.

**434 Organization and Direction of Out-of-School Programs.** Emphasis on solving problems encountered in such phases of the out-of-school program as determining instructional needs and planning programs of instruction, teaching in groups, giving individual instruction, organizing and advising the local out-of-school association, evaluating the out-of-school program.

**444 Teaching of Secondary Mathematics.** For students who have had a basic mathematics methods course, or have had some experience in teaching mathematics. Attention given to new materials and methodology in mathematics education. Special interests of students serve as guide for further selection of topics.

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

**446 General Curriculum Development.** General course in selecting and organizing into an educational plan the knowledge, skills, attitudes to be learned; evaluation for improving the plan; implementation of the plan. Experiences include (a) curriculum development labs; (b) readings, lectures, and discussions in curriculum development theory, curriculum evaluation and implementation; (c) individual project work.

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

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

**463 Sociology of Education.** Introduction to major themes in contemporary literature in sociology of education. These include social stratification and education, the school as an organization and institution, minority groups in school socialization,

professionalization of teaching, bureaucratization, teacher-student roles, career patterns of teachers.

**467 Education Law.** Review and analysis of federal and state legislation, court decisions, opinions, regulations which affect educational institutions. Attention to New York State legislation optional.

**470 Educational Issues.** Critical examination of theories, policies, practices.

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

**473 Contemporary Philosophy of Education.**

**475 Freedom and Authority on Education.** Analysis of concept of freedom in both political and psychological contexts and application of resulting analysis to problems of freedom and authority in education.

**499 Informal Study in Education.** Two purposes are sanctioned; (1) to engage in study of a problem or topic not covered in a regular course; (2) to undertake tutorial or honors study of an independent nature in the area of student's research interests. Privilege not designed to engage in a study supplementary to a regular course for the purpose of increasing content and credit allocation of the course.

**500 Special Studies.** Limited to graduate students working on theses or other research projects. Each registration must be approved by a staff member who assumes responsibility for the work.

**507 The Teaching of Science.** Consideration of learning theory as applied to problems of selection and organization of subject matter, methods of teaching and instructional innovation. Study of published research relevant to the improvement of science teaching. Conducted in 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 individual student's interest. Conducted in seminar style.

**511 Educational Psychology.** Basic course in educational psychology, for graduate students.

**522 Educating for Community Action.** Emphasis on design and execution of the educational aspects of community action programs. Identification and statement of educational goals, selection of teaching strategies, evaluation of outcomes.

**523 Administration of Continuing Education Programs.** Application of principles of administration and supervision to problems of organizing and operating continuing education programs. Emphasis on identifying, describing, analyzing alternative models for planning, organizing, staffing, directing, controlling, financing an adult education enterprise.

**524 Designing Extension and Continuing Education Programs.** Analysis of current theories, concepts, principles, procedures central in process of developing programs for continuing education of adults. Emphasis on such major problems as situation analysis, selecting objectives from alternatives, creating support at macro level, organizing program resources at micro level, planning for program execution.

**525 Educational Communication.** Emphasizes centrality of useful technology and effective communication in continuing education programs. Emerging models of communication process reviewed as a framework for analyzing major elements, including communicator credibility, program content, messages, organization and use of transmission channels, message treatment, audience identification, feedback, design of operation communication programs.

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

**527 Evaluation for Program Management.** Program evaluation treated as a part of overall task of making program management decisions. Primary attention to educational and other community change programs, but inferences to other program management tasks possible. Three aspects: (1) series of lecture-discussions; (2) continuing workshop; (3) individual student evaluation projects.

**531 Supervision in Occupational Education.** Function of supervision, program planning, supervisory techniques as applied to state programs in occupational education.

**532 Advanced Methods and Materials of Teaching Agricultural and Occupational Education.** Consideration given to analysis of selected teaching techniques and to selection, preparation, use of instructional materials.

**533 Developing Curriculum in Agricultural and Occupational Education.** Guiding principles, objectives, sources of information developed for planning curriculum. Consideration given to principles, meaning, function of occupational experience programs, and how they are planned, developed, used as a means of instruction.

**534 Education for Leadership of Youth and Adult Groups.** Designed for leaders in the field of agricultural education responsible for organizing programs. Consideration of principles involved in organizing and conducting out-of-school programs for youth and adult groups.

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

**536 Organization and Administration of Occupational Education.** Designed for teachers, high school principals, teacher trainers, supervisors, others responsible for administration of occupational programs or who wish to qualify for this responsibility. Emphasis on interpreting vocational legislation and problems of administration at local and state levels.

**539 Evaluating Programs of Occupational Education.** Students study objectives and evaluative criteria, develop criteria and procedures for evaluation of programs of occupational education in the secondary and postsecondary schools.

**540 Art of Teaching.** For students enrolled in teacher education programs.

**545 Curriculum of American Schools.** Survey of basic elements involved in making curriculum decisions, and examination of contemporary curriculum developments in elementary and secondary schools.

**547 Seminar in Career Education.** Seminar to study current problems and research in the field of career education.

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

**555 Use and Interpretation of Tests in Guidance and Personnel Administration.** Open to students in guidance or personnel administration and to classroom teachers who expect to work with standardized group tests. Deals with historical development and use and interpretation of aptitude tests as basis for guidance and selection in public schools, colleges, industry.

**561 Administration of Educational Organizations.** Consideration of current approaches to understanding administration and organizations, their application to educational setting.

**562 The Principalship.** Organized to enable recognition and cognition of administrative functions essential to effective elementary and secondary schools. Analysis includes elementary and secondary school as institutions, innovation in organization and curriculum, administration of instructional and noninstructional personnel, community relationships. Each student elects to specialize at elementary or secondary school level for an individually planned program of intensified study.

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

**565 Supervision for Improvement of Instruction.** Role and function of supervision in preservice programs and in educational professions development. Includes analysis of teaching as a

means of facilitating improved instruction in educational institutions.

**568 Public School Law.** Review and analysis of federal and state legislation, court decisions, opinion, regulations which affect New York State public schools.

**569 Personnel Development.** Development of a conceptual framework for understanding roles and functions of educational personnel responsible for personnel development, and developing skills in identifying and analyzing personnel problems, planning alternative strategies to cope with problems, evaluating selected courses of action.

**573 Structure of Knowledge Seminar.** Concept of structure of a discipline and development of a systematic method for analysis of knowledge claims. These concerns relate to nature of teaching, curriculum theory and research, educational policy, nontraditional forms of educational practice.

**574 History of American Education.** Examination of role of education in shaping American society. Chief emphasis on period from 1820 to 1914.

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

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

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

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

**584 Group Counseling.** Techniques and principles of counseling with groups. Emphasis on relationship between types of counselor interventions and development of group processes.

**585 Occupational and Educational Information.** Survey and appraisal of occupations and training opportunities. Study of sources of educational and vocational information, job analysis, vocational trends.

**586 Organization of Higher Education in the United States.** Designed to provide a broad perspective on higher education enterprise. Students gain an understanding of how higher education is organized institutionally, state-wide, nationally; they investigate critical roles and relationships which impinge on growth and development and examine current research and commentary.

**587 Practicum in Measurement and Appraisal for Counselors.** Advanced course in use of tests and test results in psychological appraisal of individuals. Emphasis on analysis of testing programs, intensive

examination of selected standardized tests, laboratory experience in interpreting test results.

**588 Case Studies in Counseling.** Advanced course in counseling in which cases are used for illustrative purposes. Preparation for and conducting of counseling interviews; making of case studies; referral and other procedures.

**589 Affective Education.** Affective education is the developing curriculum area designed to teach the student skills for understanding and guiding his own personal development. Utilizes an experience-based, participatory design to develop basic interpersonal and small group skills, and to introduce a conceptual framework for the design, application, evaluation of humanistic education techniques and courses. Appropriate for counselors, teachers, administrators concerned with the development of psychological education offerings in the school or college.

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

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

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

**602 Field Laboratory in Student Personnel Administration.** Directed field project in student personnel administration.

**606 Science Education Seminar.**

**613 Seminar in Educational Psychology.** Theoretical issues in teaching of reading.

**616 Seminar in Educational Research.**

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

**618 Seminar in Educational Psychology and Curriculum Development.** Emphasis on theoretical considerations of various areas in educational psychology. Primarily for doctoral students.

**626 Extension and Continuing Education Seminar.** Provides opportunity to analyze and reflect on current professional issues.

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

**628 Current Problems and Issues in Extension Education.** A major area of concern to extension education selected for intensive study by participating students and faculty.

**630 Seminar in Agricultural Education.** Recommended for master's degree candidates who have had teaching experience and doctoral candidates with majors and minors in agricultural education. Seminar primarily centers around current problems and research in the field not included in other course work.

**645 Seminar in Curriculum Theory and Research.** Theoretical issues in curriculum and appropriate areas for curriculum research discussed. Student expected to identify and articulate a curriculum-related problem appropriate for research.

**663 Seminar in the Sociology of Education.** Consideration of selected topics in the sociology of education relevant to organization and policy issues.

**668 Seminar in Educational Administration.** Consideration of problems and policy issues in public schools and higher education.

**669 Studies in Educational Administration.** Intended to provide beginning graduate students in educational administration with a critical introduction to research topics in this field and to inform them of potential of those topics for thesis research.

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

**671 Seminar: Analysis of Educational Concepts.**

**672 Seminar in Educational Classics.**

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

**674 Seminar in History of Education.**

**681 Seminar in Student Personnel Administration.**

**698 Practicum in Educational Research.** Participation in research project under the direction of principal investigator.

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

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

**CSE600 Special Problems for Graduate Students.**

For students recommended by their chairmen and approved by the instructor in charge for independent, advanced work.

**CSE610 Seminar in Adult Education.** Significant problem area in adult education, such as philosophy of adult education, teaching-learning process for adults, or special problems of the disadvantaged adult learner. Implications of theory and research in problem area an important consideration. Particular area to be considered to be announced at preregistration time.

**CSE616 The Facilitative Processes and the Helping Relationship.** Concentration on theory and research in facilitating helping relationship. Each class member participates in a group laboratory to develop helping skills and to undertake a research project in the area.

**CSE621 Alcohol: Problems and Community Services.** Nature and extent of various alcohol problems and delivery of services for alcoholics. Special attention to: effects of alcohol on the body, drinking trends and patterns, special problem drinking groups, legal approaches to control of alcohol problems and an overview of treatment and rehabilitation programs in various organizational settings.

**CSE623-624 Special Problems in Social Welfare.**

**CSE628 Human Services Theory and Social Policy.** Seminar provides detailed examination of various functions of social theory for study of social policy. Discussions on use of theory in social sciences for proscribing, describing, evaluating both planning and provision of social services.

**CSE630 Seminar in Human Services Training.** Weekly seminar and independent study related to 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.

**CSE631 Supervision of Paraprofessionals in Human Services.** For persons who anticipate working with paraprofessionals in community service settings. Focuses on the nature of professionalization; roots of paraprofessionalism; New Careers concept; models of utilization of paraprofessionals; recruitment, selection, training, and evaluation of paraprofessionals; team-building skills required by the professional. Organizational practices that facilitate differentiated staffing.

**CSE641 Ethnographic and Case Methods in Research.**

**CSE650 Comparative Studies of Family Education Services.** Factors related to planning educational human service programs for rural and urban families in developing countries. Methods of

need assessment, program development and evaluation appropriate to rural and urban programs.

**CSE651 Seminar on Women's Role in International Rural Development.** An examination of the status of rural women in developing countries and their potential role in raising local productivity and living levels. Focus will be upon evidence of status change in the context of social, economic, and political change.

**CSE660 Internship Planning and Program Development.** Application of planning and program development scales to current problems in state and regional planning. May involve fieldwork outside the Ithaca community.

**CSE670 Seminar in Higher Education.** Study of selected current problems in higher education, focusing on development of innovative approaches to professional education.

**CSE671-672 The Teacher Educator in Home Economics.** Opportunity for students to develop understanding of teacher education practices by observing and participating in undergraduate program. Participation involves teaching and individual work with students. Additional experiences include observation of student teachers and supervisory conferences in student teaching centers.

**CSE679 The Teaching of Home Management in College.** Examination of ways home management concepts are currently being taught and exploration of new teaching approaches.

**CSE680 Seminar in Community Service Education.** Informal seminar for graduate students and faculty. One or two major topics related to community components and dynamics or provision of educational services considered each term.

**CSE684 Bases for Instructional Program Planning.** Basic strategies for planning instructional programs. Concepts of structure, function, process in program planning and their relation to individual learning and ecological variables. Opportunity provided for students to work on projects related to their special interests.

**CSE690 Evaluation.** Basic principles of evaluation studied in relation to specific methods of appraising progress toward objectives of behavioral change. Opportunities for constructing and using evaluation instruments.

**CSE692 Survey Research Methods.** Basic course covering planning of surveys, instrument design, sampling, interviewing, other means of data gathering, field quality control, coding, machine data processing and analysis; selected special problems and techniques in field data collection and processing, including issues of survey ethics. Familiarity with elementary statistical concepts desirable, but not prerequisite.

**CSE718 Designing Human Service Programs.** Methods of translating human services research into programs for service to communities and individuals. Operational design, staffing, budget preparation, fund

raising, community auspice development, as well as evaluation, administration, program change. Students expected to fully design local service program.

**CSE773 Internship and Field Work in Teacher Education.** Involves supervision of student teachers and conferences as needed with college supervisor and cooperating teachers in schools. Provision made for a follow-up visit to a first-year teacher.

**CSE775 Administration and Supervision Practicum.** Analysis of concepts of administration and supervision in agencies and institutions concerned with educational aspects of human services through direct observation of state, local, college programs. Approximate cost of field trips, \$35.

**CSE790 Seminar in Evaluation.** Opportunity for intensive study of literature concerning selected topics in evaluation, for refinement of appraisal techniques, for carrying out an evaluative study related to current departmental research.

**CSE899 Master's Thesis and Research.**

**CSE999 Doctoral Thesis and Research.**

## Electrical Engineering

### Theory of Systems and Networks

**IEE420 (4450) Bioelectric Systems.** 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, 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.

**IEE621 (4453) Introduction to Biomechanics, Bioengineering, Bionics and Robots.**

**IEE623 (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 discrete Fourier transform (DFT). Design of nonrecursive and recursive digital filters. Realizations of digital processing algorithms by either

software procedures or hardware implementations. Fast Fourier transform (FFT) algorithms. Topics for optional laboratory: 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.

**IEE624 (4478) Computer Methods in Electrical Engineering.** Designed to present modern techniques for solving electrical engineering problems on digital computer. Emphasis on efficiency (minimizing operation counts) and numerical stability rather than theoretical implications. Laboratory used for experimenting with algorithms in 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.

**IEE625 (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.

**IEE721 (4503) Theory of Linear Systems.** State-space model for linear systems. Properties of ordinary linear differential equations. Fundamental and transition matrices. Matrix exponential functions, Cayley-Hamilton theorem and 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.

**IEE722 (4504) Theory of Nonlinear Systems.** Analysis of first- and second-order nonlinear systems with applications. Phase plane analysis of autonomous systems; singular points, limit cycles, equilibrium states; theories of Bendixson, Lienard, and Poincare; relaxation behavior in phase plane; stability of nonlinear systems, the methods of Lyapunov and Popov, circle criteria. Forced nonlinear systems harmonics, subharmonics, jump phenomena, frequency entrainment; periodic systems, Floquet theory, Mathieu-Hill theory,

applications to stability of nonlinear systems and to parametrically excited systems.

**IEE723 (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.

**IEE724 (4572) Network Theory and Applications.** 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.

## Electronics

**IEE430 (4430) Introduction to Lasers and Optical Electronics.** Introduction to stimulated emission devices such as masers, lasers, optical devices based on linear and nonlinear responses to coherent fields. Material discussed based on quantum mechanical results but employs 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, includes atom, ion, molecular, 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 Siegman.

**IEE432 (4412) Solid State Physics and Applications.** Introduction to solid state physics with emphasis on applications to electronic devices. Classical concepts of solid-state physics, including crystal structure and symmetries, X-ray diffraction, Brillouin zone representation of periodic structures, band theory, phonon interactions, superconductivity, introduced and related to latest concepts and devices of electronic engineering. Some engineering problems discussed briefly in this context are Gunn Effect for generation of microwaves, integrated circuit technology as dependent upon crystalline properties, Josephson effect, superconducting electric transmission lines. Interaction-recitation period used for discussion of reading and lecture material, problem solution, laboratory demonstration of some physical principles and engineering problems

discussed in lecture. At the level of introduction to *Solid State Physics*, 4th Edition, by Kittel.

**IEE531-532 (4431, 4432) Electronic Circuit Design.** Design techniques for circuits used in electronic instrumentation. Circuits designed to provide specific functions, then constructed and tested in laboratory. At the level of *Pulse Digital and Switching Waveforms* by Millman and Taub.

**IEE631 (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.

**IEE632 (4434) Semiconductor Electronics II.** Continuation of IEE 631 with emphasis on 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.

**IEE633-634 (4437-4438) Solid State Microwave Devices and Subsystems I and II.** 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, transistor. Initially, basic elements of microwave systems and subsystems such as oscillators, amplifiers, modulators, detectors studies, and then more complex elements such as microwave cavities, filters, microwave network analyzers, superheterodyne receivers, spectrum analyzers, noise measuring equipment, time domain reflectometers, experimental Doppler Radars. Typical uses of solid state devices in these subsystems discussed and analyzed. In many cases subsystems themselves used to characterize circuit parameters of microwave solid state devices and other subsystems. Opportunity to study and operate wide variety of modern test equipment such as H.P. Network Analyzer, Sampling Oscilloscopes, near-carrier oscillator noise test sets, Spectrum Analyzers, microwave laboratory test bench equipment. Participation in 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.

**IEE635 (4537) Integrated Circuit Technology.** Integrated circuit techniques applicable in fields of computer hardware, telecommunication systems, optoelectronics studied, emphasis on device technology and specialized approaches to device, circuit, system design required by large-scale function integration. Computer logic and memory elements, both MOS and bipolar, discussed.

Telecommunication applications include linear ICs and hybrid integration of microwave solid state devices, such as Gunn and IMPATT oscillators in transmitters and receivers. Integrated optics and compound semiconductor light-emitting and sensing devices covered. To illustrate techniques discussed, each student fabricates planar silicon diodes or transistors in microelectronics laboratory; project students later work on their own in laboratory on topics of their choice, such as microwave integrated circuits, integrated gates, optoelectronic devices. At the level of current papers in *IEEE Journal, Solid State Circuits* and *IEEE Transactions on Electron Devices*.

**IEE636 Circuit Design for Integration.** Details of circuit design for integration in silicon monolithic integrated circuits and hybrid microwave integrated circuits discussed. Limitations of and advantages afforded by physics and technology of processes involved in fabrication of these circuits, developed in relation to circuit design. Techniques for complete vertical integration of complex systems, from materials preprocessing up through design to optimize final testing, emphasized. Topics: component-dictated limitations on IC design; specialized functional blocks for linear and digital ICs; special components available to monolithic IC designers (e.g., multiple-collector transistors); feedback in linear IC design; chip layout; thermal considerations. Merging of design techniques for microwave integrated circuits and gigabit data rate digital ICs also discussed. Class undertakes design/fabrication project. Device physics considered at the level of *Physics and Technology of Semiconductor Devices* by Grove; additional reading at the level of current papers in the *IEEE Journal of Solid State Circuits*, and *Solid State Electronics*.

**IEE731 (4531) Quantum Electronics I.** Detailed treatment of physical principles underlying optical masers, related fields, applications. Topics include: review of quantum mechanics and quantum theory of angular momentum; interaction of radiation and matter; quantum mechanical density matrix and macroscopic material properties; theory of laser and maser. At the level of *Quantum Electronics* by Yariv and *Fundamentals of Quantum Electronics* by Pantell and Puthoff.

**IEE732 (4532) Quantum Electronics II.** Continuation of treatment of physical principles underlying optical masers and related fields. Topics: 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.

**IEE733 (4533) Optoelectronic Devices.** Variety of optoelectronic devices considered. Provides physical understanding of some properties of solids which affect their use in optical devices. Topics: review of macroscopic theory of electromagnetic waves in isotropic, lossy and anisotropic media; symmetry

group theory of crystals; discussion of linear electrooptic devices such as modulators and deflectors; classical and quantum-mechanical treatment of microscopic theory of dielectric constant and absorption in solids due to electronic transitions, including interband and intraband, impurity, surface state and exciton processes. Band theory of photoemission discussed. Physics of hot and cold carrier transport, including effects of trapping, recombination, scattering; photoconductivity in solids and noise in optical detectors. Principles illustrated by their application to performance analysis of actual photoconductive, thermal, photomissive detectors. Treatment of gain and loss mechanisms in semiconductor lasers and light-emitting diodes and performance analysis of semiconductor lasers. Topics mainly concerned with semiconductors, but metals and insulators not excluded. At the level of *Dielectrics and Waves* by von Hippel, *Photoconductivity of Semiconductors* by Bube, *Physical Properties of Crystals* by Nye, *Quantum Electronics* by Yariv, and *Optical Processes in Semiconductors* by Pankove.

**IEE734 (4534) Theory and Applications of Nonlinear Optics.** Detailed study of recent developments in the theory and applications of nonlinear optics and related electrooptic devices. Topics: properties and theories of nonlinear optical processes; nonlinear and electrooptic properties of III-V and II-VI compounds and other optical materials; optical mixing; frequency up-conversion and down-conversion; spontaneous and stimulated processes involving nonlinear interactions of electromagnetic waves, phonons, molecular vibrations; electrooptical modulators, optical parametric oscillators, other nonlinear optical devices. At the level of *Treatise in Quantum Electronics, Vol. 1-Nonlinear Optics*, edited by Rabin and Tang, current literature.

**IEE735 (4535) Solid State Devices I.** Study of properties of semiconductor devices with emphasis on low-frequency operation (below 1000 MHz). Devices based on 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 diode, Schottky triode. Emphasis on determining factors underlying performance capabilities. Equivalent circuits developed. Students either carry out term laboratory project or prepare term paper on appropriate contemporary topic. Presented at the level of *Physics of Semiconductors* by Moll and of current papers published in the *IEEE Transactions on Electron Devices*.

**IEE736 (4536) Solid State Devices II.** Study of properties of semiconductor devices with emphasis on high frequency operation (above 1000 MHz). Approaches to analysis 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, other contemporary devices. Emphasis on determining factors that underlie performance capabilities. Equivalent circuits developed. Students either carry out term laboratory project or prepare term paper on an appropriate contemporary topic. Presented at the level of current papers published in the *IEEE Transactions on Electron Devices*.

**IEE737 (4631) Physics of Solid State Devices I.** Phenomena and problems associated with conduction in high electric fields considered; emphasis mainly on semiconductors. A review given of hot electron phenomena, especially where instabilities arise because of multivalley band structure or other interaction of charge carriers with host crystal. Basic theory of electron and hole scattering by phonons covered and methods of obtaining distribution functions from Boltzmann equation examined. Modifications required by complications of band structure discussed.

**IEE738 (4632) Physics of Solid State Devices II.** Analysis of solid state devices of current interest (avalanche, LSA, Gunn devices, etc.) considered in sufficient detail to give an understanding of some of limitations involved in the design of such devices. Particular scattering mechanisms and band structure complications considered in obtaining realistic distribution functions. Emphasis on analytical solutions because of physical insight they afford, but numerical methods also considered. The number of devices considered limited, but subjects of specific interest to individuals can be considered on a seminar basis.

## Power Systems and Machinery

**IEE551 (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, mechanical systems; control of magnetic field distribution by reluctance and winding distribution; traveling fields from polyphase excitation; elementary idealized commutator-type, asynchronous, synchronous machines.

**IEE552 (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, amplitudynes, frequency converters.

**IEE553 (4443) Power System Equipment.** Engineering responsibilities for system equipment and control studied. Emphasis on producer-user relations for catalog or built-to-order items. Calculations and test requirements of electrical

apparatus for electrical power production, distribution, use considered. Prime movers, generators and their accessories, switchgear, protective devices, power transformers, converters, towers, conductors, regulating devices analyzed. Inspections of nearby plants and equipment supplement classroom work.

**IEE554 (4444) High-Voltage Phenomena.** Study of problems of normal operations of power apparatus at very high voltages. Abnormal conditions imposed by lightning and methods employed to assure proper operation considered. Laboratory testing of equipment under actual or simulated conditions, being an essential step in engineering design of high-voltage apparatus, given particular attention. Considerable attention given to dielectric behavior, traveling wave, dielectric testing techniques. Electrical manufacturing test facilities visited.

**IEE651 (4445) Electric Energy Systems I.** Physical and engineering principles underlying steady state operation and control of modern electric power systems, with emphasis on characteristics of major power-system parameters. Theory of electromechanical energy converters, power transformers, conventional transmission lines and cables, power networks, other power-system components; use of digital computer as a dynamic "laboratory" model of a complex power system for load-flow studies. Laboratory-computing periods include selected experiments with small electromechanical energy converters. At the level of *Elements of Power System Analysis* (2nd ed.) by Stevenson.

**IEE652 (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 digital computer for fault studies and economic analysis. At the level of *Elements of Power System Analysis* (2nd ed.) by Stevenson.

## Communications, Information, and Decision Theory

**IEE661 (4473) Coding Algorithms.** Coding algorithms for compression and storage of information, for correction of errors in digital data processing and transmission, 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, evaluation of coding algorithms covered in lecture. At the level of *An Introduction to Error Correcting Codes* by Lin.

**IEE662 (4474) Fundamental Information Theory.** Fundamental results of information theory and their

application to information storage, compression, processing, and transmission. Basis of modern design of digital communication systems. Source coding, properties of entropy, 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), evaluate advantages and limitations of various coding algorithms introduced in 4473. At the level of *Information Theory* by Ash.

**IEE663 (4476) Statistical Aspects of Communication.** Analysis of analog and digital communication systems in presence of random signals and noise. System optimization, matched filters, linear smoothing, 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.

**IEE664 Decision Making in Pattern Classification.** Concepts and key results of decision theory developed and applied to problems of pattern classification (hypothesis testing). Typical pattern classification problems include classification of hand-written, typed or printed alphanumeric characters, transcription of speech, identification of regions in photographs, medical diagnosis. Formulations of design of pattern classification systems examined under variety of assumptions concerning prior information about pattern source and objectives in constructing such a system. Design philosophies discussed include those of minimum expected loss, Neyman-Pearson, minimax risk and regret. Laboratory projects require computer-based design and simulation of a pattern classifier for real or simulated pattern source.

**IEE761-762 (4507-4508) Random Processes in Electrical Systems I and II.** Concepts of randomness and uncertainty and their relevance to design and analysis of electrical systems. An axiomatic characterization of random events. Probability measures, random variables, 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,

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.

**IEE763 (4674) Advanced Information Theory.** In-depth treatment of an information theory research area. Topic varies from year to year and is chosen from the following: source encoding (rate distortion theory), convolutional codes and sequential decoding, multiterminal communication networks, ergodic theory and information in abstract spaces, complexity and instrumentability of coding schemes.

**IEE764 (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. Discussion of foundations of inference centers on various approaches to interpretation and formalization of probability, including the following: axiomatic systems of comparative probability; Komogorov system of quantitative probability; relative frequency interpretations; computational complexity, randomness, probability; classical probability and invariance; logical probability and induction; subjective probability and personal decision making. Discussion of foundations of decision making centers on utility theory, axiomatic rationality, statistical decision theory, nature of a good system, recent work on system design when there is little prior information.

**IEE765 (4673) Principles of Analog and Digital Communication.** Fundamentals of information theory, signal theory, statistical estimation and decision theory used to formulate approaches to the solution of problems arising in digital and analog communication. Particular topics: receiver and signal design, probability of error, capacity, threshold effects for additive Gaussian channel. Extensions to 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.

## Computing Systems and Control

**IEE671-672 (4481-4482) Feedback Control Systems.** 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 Laplace transform; transfer functions. State-space approach to control systems; observability, controllability. 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. 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, analysis of nonlinear and sampled-data systems using analog and digital computers.

**IEE673 (4483) Hybrid Computation I.** Basic concepts and principles of hybrid computation as applied to problems in engineering analysis, simulation and design; analog computation and the design of special purpose patchable logic programs that are used to support analog computation; the digital computer in a hybrid environment. Laboratory work with general-purpose analog computers, patchable logic systems and the PDP-11/TR-48 hybrid computer system. At the level of *Analog and Digital Computer Methods in Engineering Analysis* by James, Smith and Wolford.

**IEE674 (4484) Hybrid Computation II.** Theory, design, characteristics, programming of 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 identification, the maximum principle. Laboratory work with the PDP-11/TR-48 and the AD-40 hybrid computers. At the level of *Hybrid Computation* by Bekey and Karpilus.

**IEE675 (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 optional laboratory session: design and construction with MSI modules of counters, shift registers, adders, other arithmetic circuits in digital computers. At the level of *Switching Circuits: Theory and Logic Design* by Torng.

**IEE676 (4488) Computer Structures.** Architecture and design of computing systems; configuration of components, memory organization; central processing unit design; microprogramming; input-output management, channel controller; interrupt; performance evaluation. Topics for optional laboratory session: design and implementation of small scale general purpose or special purpose calculators and computers. At the level of *Computer Structures: Readings and Examples* by Bell and Newell.

**IEE771 (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 assumed; APL language learned during term through use of library of programs written for the course. At the level of *Stochastic Optimal Linear Estimation and Control* by Meditch.

**IEE772 (4506) Optimal Control and Estimation for Continuous Systems.** Methods of design problem formulation, computational techniques, and mathematical background developed for the implementation of continuous optimal control and estimation. Deterministic and stochastic controls as well as unbiased estimators formulated on both finite and infinite time intervals. Extensive examples given such as re-entry vehicle flight-control, rocket-booster guidance, aircraft tracking, and human operator simulation. Methods of successive approximation and substitution presented for minimization with respect to parameters and functions, with and without equality and inequality constraints. Properties of Lyapunov and Riccati equations discussed. Material illustrated by student use of APL library of computer programs for automated design of continuous controls and estimators.

**IEE773 (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.

## Radio and Plasma Physics, Electromagnetic Theory

**IEE581 (4461) Wave Phenomena in the Atmosphere.** Elementary treatment of wave phenomena in atmosphere of earth, including gravity waves, planetary waves, acoustic waves, radio waves, plasma waves; role of these phenomena in various atmospheric processes and engineering problems such as weather, diffusive transport air/sea interaction, radio communication, remote sensing.

**IEE582 (4462) Radio Engineering.** Study of electrical systems for communications, control, detection, other purposes in which radiowaves play a central role: system functions, including generation, modulation, transmission, reception, demodulation; guidance, radiation, and propagation of radiowaves, including transmission lines and waveguides, antenna systems, effects of atmospheric inhomogeneity; system design problems.

**IEE680 (4464) Elementary Plasma Physics and Gas Discharges.** Review of electromagnetic wave theory and application. 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.

**IEE681 (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, microscopic instabilities; test particle in a plasma; elementary applications. At the level of *Elementary Plasma Physics* by Longmire.

**IEE682 (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; neoclassical toroidal diffusion, relativistic beams.

**IEE683 (4511) Electrodynamics.** Foundations of electromagnetic theory. Maxwell's equations, electromagnetic potentials, 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.

**IEE684 (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 multipoint 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.

**IEE685-686 (4551-4552) Upper Atmosphere**

**Physics I and II.** Physical processes governing behavior of earth's ionosphere and magnetosphere. Topics: diagnostic measurement techniques; production, loss, transport of charged particles in ionosphere and magnetosphere; temperature variations; airglow; tidal motions, winds, gravity waves in ionosphere; electrical conductivity of ionosphere, dynamo current system, equatorial and auroral electrojets; plasma instabilities in ionosphere; interactions between ionosphere, magnetosphere, solar wind; acceleration and drift of energetic particles in magnetosphere; precipitation of particles and aurora; magnetic and ionospheric storms. At the

level of *Introduction to Ionospheric Physics* by Rishbeth and Garriott.

**IEE687 (4565) Radiowave Propagation I.**

Antennas: radiation dipoles and loops, antenna arrays, radiation from apertures, spherical and parabolic reflectors. Propagation in earth's environment: troposphere, ionosphere, magnetosphere, interplanetary space. Diffraction and surface wave propagation; tropospheric refraction and ducting; propagation in ionospheric plasma, including magnetoionic theory, CMA diagram, cross modulation and Faraday rotation, whistler mode propagation, ion effects and ion whistlers, group velocity and ray tracing. WKB solutions of coupled wave equations.

**IEE688 (4566) Radiowave Propagation II.**

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

**IEE689 (4567) Antennas and Radiation.**

Formulation of 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, 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 conducted on an antenna range. At the level of *Electromagnetic Waves and Radiating Systems* by Jordan.

**IEE781 (4661) Kinetic Theory.** Designed for students wishing firm foundation in fluid dynamics, plasma-kinetic theory, nonequilibrium statistical mechanics. Brief review of classic dynamics. Concept of ensemble and theory of Liouville equation. Prigogine and Bogoliubov analysis of BBKGY sequence. Chapman-Kolmogorov analysis of Markovian kinetic equations. Derivation of fluid dynamics. Kinetic formulation of stress tensor. Boltzmann, Krook, Fokker-Planck, Landau, Balescu-Lenard equations. Properties and theory of linear Boltzmann collision operator. Chapman-Enskog and Grad methods of solution of Boltzmann equation. Klimontovich formulation. Coarse graining and ergodic theory. At the level of *Introduction to the Theory of Kinetic Equations* by Liboff.

**IEE782 (4664) Nonlinear Phenomena in Plasma**

**Physics.** Thorough treatment of nonlinear processes in plasmas and their implications for such diverse fields as controlled thermonuclear fusion and space plasmas. In two parts. (1) Coherent nonlinear processes: echoes, trapped particles, solitary waves,

shocks and parametric instabilities. (2) Statistical theories of plasma turbulence: quasilinear theory, wave kinetic equations, the random phase approximation, resonant mode-mode coupling, nonlinear Landau damping, Dupree's theory of strong plasma turbulence, anomalous resistivity and diffusion, turbulent heating. At the level of current articles in *Physics of Fluids* and *Journal of Experimental and Theoretical Physics (Soviet Physics)*.

## General

**IEE591-592 (4591-4592) Project.** Individual study, analysis, and, usually, experimental tests in connection with special engineering problem chosen by student after consultation with faculty member directing his project; an engineering report on project required.

**IEE691-699 Special Topics in Electrical Engineering.** Seminar, reading course, or other special arrangement agreed upon between students and faculty members concerned.

**IEE791-792 (4691-4692) Electrical Engineering Colloquium.** For graduate students enrolled in the Field. Lectures by visiting authorities, staff and graduate students. Weekly meeting for presentation and discussion of important current topics in the field.

**IEE793-794 (4595-4596) Electrical Engineering Design.** For students enrolled in M.Eng. (Electrical) program. Utilizes real engineering situations in which to present fundamentals of engineering design.

**IEE795-799 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

In the following group the topic varies from year to year in those courses marked with an asterisk.

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

**602 Beowulf.** Reading of poem in Old English and discussion of literary and historical problems which it presents.

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

**604 Medieval Drama.** Dramatic forms and traditions from liturgical drama to Elizabethan period.

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

**610 Grammatical Analysis.** Study of structures of English revealed in transformation of basic components of predication.

**621 Studies in the Sixteenth Century.**

**625 Studies in Elizabethan and Jacobean Drama.**

**627 Studies in Shakespeare.**

**629 Studies in Milton.**

**634 Restoration and Eighteenth-Century Drama.**

Emphasis on Etheredge, Wycherley, Dryden, Congreve, Gay, Fielding. Study of genre changes in the context of literary criticism, political and social pressures, theatre history.

**\*635 The English Novel in the Eighteenth Century.**

**\*641 Studies in Romantic Literature.**

**\*646 Studies in Victorian Prose.**

**\*647 Studies in Victorian Poetry.**

**\*648 Studies in Victorian Fiction.**

**\*652 Studies in Modern Fiction.**

**\*654 Studies in Modern Poetry.**

**\*656 Studies in Modern Drama.**

**\*660 The Political Novel in America.**

**\*661 Studies in American Literature.**

**\*662 Studies in Nineteenth-Century American Literature.**

**\*665 Studies in Modern American Poetry.**

**\*666 Studies in Contemporary American Literature.**

**667 Political Religion in America.** Historical study of political consequences of religiously oriented movements in America with special attention to issues of revivalism, revolution, disestablishment, antislavery, Social Gospel, nonviolent resistance, millennialism, First Amendment clauses.

**668 Studies in American Culture.** The 1930s.

**\*672 Studies in Dramatic Literature.**

**\*673 Literary Criticism.**

**674 Studies in Biography.** Study of lives by Plutarch, Walton, Johnson, Boswell, Carlyle, Freud, Strachey, Woolf, Erikson, others. Some emphasis on relation of biography to novel and to history, psychology, autobiography, other disciplines in order to explore main theoretical and critical problems posed by the art of biography.

**675 Studies in the English Language.** Historical survey of English; study of language in general and structure of modern English; teaching communication skills.

**\*676 Studies in Anglo-Irish Literature.**

**678 The Teaching of English.** Problems and methods of teaching English in high school.

**698 Critical and Scholarly Perspectives I.** Inductive approach to important problems in scholarly investigation and critical discussion of literature as these emerge in a close study of

selected masterpieces of English or American literature. Beginning Ph.D. students urged to enroll in this course or its spring-term counterpart, English 699.

**699 Critical and Scholarly perspectives II.**

**779 Practice Teaching.** For M.A.T. candidates in English.

**780-781 Creative Writing.** Required for M.F.A. candidates.

**794 Directed Study.** Usually but not necessarily taken early in student's graduate career. Under supervision of a professor works are read which relate to student's individual program of study, or, which explore areas in which no appropriate seminars are offered. Subject matter; problem formulated by student (perhaps culminating in a paper), or background material relevant to student's major interests, or both.

**795 Group Study.** Counsel formulated by students in which they meet to consider problems or areas of mutual interest, under sponsorship of one or more professors.

**796 Teaching and Research.** Combines participation (including some teaching) in a professor's undergraduate course with reading supervised by same professor.

**798 Master's Essay.**

The Department also offers each year a number of other graduate seminars in particular historical periods, authors, and special topics. Lists of current courses are available upon request.

## Entomology

### General

**212 Insect Biology.**

**518 Techniques of Biological Literature.**

### Apiculture

**260 Introductory Beekeeping.**

**262 Biology of the Honey Bee.** Laboratory and field course. Classical experiments on vision, chemical senses, language of the honey bee, as described by von Frisch, repeated. Laboratories include demonstration of sex attractant, swarm orientation, natural nest, study of wasp, bumble bee, other social insect nests.

### Environmental Entomology

**400 Insect Ecology.** Familiarity with principles of ecology assumed; emphasis on integrating these ideas through detailed analysis of entire life systems. Adaptive strategies of insects, functional role of arthropods in terrestrial ecosystems, methods of sampling, natural history of major arthropod guilds,

contrast between natural and managed systems, principles of functional analysis.

**471 Bionomics of Freshwater Invertebrates.** Field and laboratory study focused on aquatic insects, also including the Crustacea, Mollusca, other macroscopic invertebrates. Identification of these organisms, understanding where and how they live, consideration of physical and chemical conditions and ecological relationships in different freshwater biotopes.

**577 Biological Control.** Theory and method of biological control of arthropod pests and weeds.

**595 Environmental Biology.** Consideration to current environmental problems, with particular emphasis on "systems approach" to population management.

**660 Insect Ecology Field Course.** Methods for study of insect populations and communities. Class engages in coordinated set of projects during 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

**241 Introductory Applied Entomology.** Life histories of insects of direct importance to agricultural production, procedures of detection, identification, methods of control.

**340 Insect Pest Management.** Lecture and laboratory introduction to principles and techniques of insect pest management as these relate to diverse problems in contemporary economic entomology.

**341 Arthropod Pests of World Importance.** Survey of life histories and socioeconomic importance of arthropod pests of world significance.

**342 Special Topics in Economic Entomology.** Topics: legislation and regulation of pesticides, pesticide application techniques, and others.

### Medical Entomology and Insect Pathology

**452 Medical Entomology.** Insects and other arthropods of public health and veterinary importance. Manner in which these arthropods transmit pathogens and principles and practice of vector control discussed.

**453 Insect Pathology.** Survey of diseases of insects caused by viruses, bacteria, fungi, and protozoans with special emphasis on pathogenesis, pathologies, epidemiology. Role of microbial disease in natural and applied insect control.

### Taxonomy, Morphology, and Acarology

**322 Insect Morphology.** Introduction to external and internal anatomy of insects, emphasis on

comparative and functional aspects. Laboratory devoted largely to dissection.

### 331 Introductory Insect Taxonomy.

**521 Acarology.** Introduction to taxonomy, morphology, bionomics of mites and ticks, with emphasis on taxa of economic importance. A collection required.

### 531 Taxonomy of the Smaller Orders of Insects.

Lectures on classification, evolution, bionomics of orders and families of insects, exclusive of larger orders of Holometabola. Laboratory studies on literature, characters, classification of representative genera and species. For continuation of taxonomy of Holometabola, see 532, 533, 534.

### 532 Taxonomy of the Immature Stages of Holometabola.

### 533 Taxonomy of the Coleoptera and Lepidoptera.

### 534 Taxonomy of the Diptera and Hymenoptera.

## Physiology, Biochemistry, and Insecticidal Chemistry

**583 Insect Physiology, Lectures.** Introductory physiology of insects. Primarily for graduate students in entomology, or physiology majors.

**584 Insect Physiology, Laboratory.** Should be taken in conjunction with 583.

### 587 Insect Biochemistry.

### 590 Insect Toxicology and Insecticidal Chemistry.

Chemistry of insecticides and their metabolism and mode of action in insects and mammals.

## Research or Special Topics

### 507 Special Topics for Graduate Students.

### 508 Graduate Research.

### 509 Teaching Entomology.

**Jugatae Seminar.** Conducted by Jugatae, the entomology club of Cornell, to discuss topics of interest to its members and guests.

## Floriculture and Ornamental Horticulture

The Department of Floriculture and Ornamental Horticulture offers courses which are available to graduate and undergraduate students. 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, Landscape Architecture, Plant Breeding and Biometry, Plant Pathology.

## Food Science and Technology

**300 Physical Chemistry of Foods I.** Application of physicochemical principles to understanding of complex behavior of food systems and biological materials. Study of principles involved in behavior of emulsions and colloidal suspensions. Properties of solutions, reaction rates, electrolytic dissociations, hydrogen ion concentration, oxidation reduction potential, photochemistry, introduction to energy relationships.

### 301 Nutritional Aspects of Raw and Processed Foods.

Nutritional problems related to food processing and evaluation of processed food. Advantages and disadvantages of food processing; appreciation of how food technological and agricultural advances have influenced and can influence nutritional well-being of mankind.

**302 Introduction to Food Engineering.** Engineering aspects of dairy and food plant operations.

### 304 Sanitary Principles and Public Health.

Biological and chemical control of food contamination and processing. Public Health, USDA, FDA, other requirements for production, protection, processing of foods. Quality assurance in foods.

**401 Concepts of Product Development.** Discussion of sequence of events involved in development and marketing of food products. Topics: packaging and labeling, legal and functional ingredient restrictions, taste panels and in-store testing, patents, pricing.

**402 Product Development Laboratory.** Laboratory taken concurrently with 401 lectures. Emphasis on gaining practical experience in formulation and processing of new foods.

### 403 International Food Science and Development.

Study of programs, technical problems, progress associated with developing, processing, marketing acceptable foods throughout the world. Expanding protein resources for man in critical areas. International aspects of pollution and public health related to food. Special attention to organization, operations, relationships, contributions of UN technical agencies, FAO, UNICEF, WHO, governmental and nongovernmental organizations in the field.

### 404 Food Processing I: Drying, Freezing, Heat Preservation.

Principles and practices of drying, freezing, canning, other heat treatments applied to foods. Current processing methods as related to the chemistry, microbiology, technology of ingredients and final products.

### 405 Food Processing II: Concentrating,

**Separating, Mixing.** Principles and practices of evaporation, reverse osmosis, filtration, centrifugation, homogenization, mixing, size reduction, other unit operations important in food industry.

### 406 Food Processing III: Fermentations.

Principles and processes leading to important foods such as fermented milks, yogurt, cheese, wines, beers. Consideration of other fermentations resulting in

foods from plant, animal, enzyme sources. Demonstration and field trips acquaint students with fermentation and enology principles and with physical and sensory qualities of above foods.

**407 Food Processing IV: Fats and Oils.** Sources, composition, properties of edible fats and oils. All classes of lipids and their effects on food quality and storage stability. Factors affecting chemical and physical stability of food fats. Chemical technology of shortenings, edible oils, margarine, butter.

**409 Food Chemistry.** Effect of chemical composition on properties of foods. Special attention to factors affecting variations in composition and consequent changes in flavor, color, texture.

**410 Sensory and Objective Evaluations of Foods.** Sensory techniques used to evaluate flavor, color, texture of foods and effect of these properties on consumer acceptance. Objective methods for measuring these qualities.

**411 Food Mycology.** Those groups of fungi important for their beneficial and harmful effects in food production, preservation, spoilage; use of fungi as food.

**412 Aquatic Microbiology.** Relation of microorganisms, especially bacteria, to aquatic environments, both natural and artificial. Microbiology of waste waters. Fundamental biological concepts and applied aspects of occurrence and activities of microorganisms in waters.

**415 Principles of Food Packaging.** Basic properties of some packaging materials and systems; these principles utilized to describe packaging systems for specific applications (e.g., meats, dairy products, fruits and vegetables, fats and oils, etc.). Engineering considerations not stressed.

**501 Proteins and Food Enzymes.** General properties of proteins: structure, preparation, reactions. Proteins as part of food systems, occurrence and composition, associations and structures, reactions to processing. Use and application of enzymes in food industry.

**502 Food Lipids.** Disposition of lipid materials in foods and manner in which lipids influence chemical and physical attributes of various foods. Effects of production techniques, storage, heating, refrigeration, enzymes on food lipids, and chemical mechanisms involved. Importance of lipids in formation of food flavors.

**503 Food Carbohydrates.** Consideration of chemistry of carbohydrates in foods, including sugars, starches, pectins, gums, cellulose. Emphasis on their origin in raw materials and subsequent changes occurring during processing and storage.

**504 Chemistry of Dairy Products.** Study of milk constituents and physical properties. Milk enzymes, lactose, milk fat, milk proteins, minor constituents.

**505 Physical Chemistry of Foods II.** Physical chemical principles of important food systems with special emphasis on colloids and emulsions.

Reaction kinetics, thermodynamics, molecular interactions.

**506 Instrumental Methods.** Instrumental methods widely used in research and industry. Major emphasis on chromatography, spectroscopy, electrophoresis, ultracentrifugation, thermal analysis, the use of computers. Practical use of material presented stressed.

**507 High-Protein Food Technology.** Needs, types, processing techniques, nutritional qualities, economics of high-protein foods for an expanding world population examined in discussions and through individual study. Basic protein foods from cereals, pulses, oil seeds, milk, marine life; single-cell protein foods from whey, cellulose, leaves, petroleum.

**508 Food Color and Food Pigments.** Introduction to theories of color perception and color spaces; survey of chemical and physical properties of the major food pigments and their stability during processing and storage. Compounds compared for color contributions and other functional properties. Color and pigments of selected commodities examined in detail.

**509 Rheology.** Fundamental concepts of rheology as applied to foods; emphasis on objective methods for measuring physical properties of foods. Principles and practice involved in measuring of solid foods, viscosity of liquid foods, consistency of semisolid foods, instrumentation, correlations between objective and sensory methods of texture measurements. Examples of rheological problems in each major food group discussed.

**510 Introductory Chemical Toxicology.** Introduction to concepts of toxicology as related to foods: physiologically active compounds in natural and processed foods; antinutritive substances; intentional food additives; potential contaminants. Safety evaluation and regulation of foods. Assigned writing or brief student lecture to widen knowledge of current research.

**599 Preparation for Food Science Teaching.** Some experience in teaching and in preparation of courses. Participants assist professor in regular food science courses, including some actual teaching experience, and attend a number of orientation lectures on teaching techniques.

**600 Seminar.** Required of all Food Science graduate students.

**Microbiology 391 Advanced General Microbiology.**

**Microbiology 394 and 395 Food Microbiology Lecture and Laboratory.**

**Animal Science 290 Meat and Meat Products.**

**Animal Science 490 Science and Technology of Meat 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.** Introduction to biological heredity through consideration of genetics of man. Intended primarily to contribute to student's general education in matter of advances in science of genetics, and effect on man's understanding himself and on his potential for influencing his present and future well being. Not prerequisite to advanced courses in genetics, although certain aspects of genetics considered. Not generally regarded as graduate course, but may be in special cases.

**281 Genetics.** General study of fundamental principles of genetics in eucaryotes, procaryotes, viruses. 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. Students perform experiments with microorganisms and conduct independent study of inheritance in *Drosophilla*.

**347 Cytology.** Study primarily of structure of cells and their components and the relation of these to function and heredity. Special attention to chromosomes. Both plant and animal materials used.

**387 Molecular Aspects of Development.** Analysis at cellular and subcellular level of regulation of synthesis and activity of gene products in development of eucaryotes. Selected systems discussed which demonstrate differential regulation of nucleic acid and protein synthesis within individual cells as well as between different populations of cells within a developing organism. Consideration to development of cell organelle systems.

**440 Cytogenetics.** Advanced course. Cellular mechanisms of heredity, including recent researches in cytology, cytogenetics, cytotaxonomy.

**480 Population Genetics.** 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 algebraic aspects of population genetics.

**484 Molecular Evolution.** Analysis of evolutionary changes in proteins and nucleic acids and gene-enzyme variability in natural populations. Role of natural selection in effecting these changes and maintaining genetic variation at molecular level critically examined. Theories on evolution of genetic code and construction of phylogenetic trees from biochemical data discussed.

**485 Microbial Genetics, Lectures.** Genetics of bacteria and their viruses; emphasis on mechanisms of genetic phenomena.

**486 Microbial Genetics, Laboratory.** Problem solving in bacterial genetics.

**488 Genetics of Lower Eucaryotes.** Genetic aspects of biology of a few eucaryotic microorganisms, primarily yeast, *Neurospora*, ciliated protozoa; emphasis on use of these organisms as experimental tools. Major topics: gene action, control mechanisms, cytoplasmic genetic systems, recombination and conversion, morphogenetic systems, evolutionary aspects of physiological systems. Extensive reading in original literature of genetics.

**489 Research In Genetics and Development.** Practice in planning, conducting, reporting independent laboratory and/or library research programs.

**680 Current Topics In Genetics.** Seminar course with critical presentation and discussion by students of original research papers in a particular area of current interest. Content of 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**

Graduate students who enter the Field of Geological Sciences without previous training or with limited training in geology may take the undergraduate core courses 325, 344, 345, 355, 356, 376, 388, and 488 to develop their proficiency in geology.

**423 Petroleum Geology.** Sedimentation and tectonics as conditions of hydrocarbon entrapment. Problems of petroleum exploration, including geophysical investigations, subsurface mapping, the movement of underground fluids, the geophysical properties of subsurface fluids and sediments. Organization and operation of petroleum industry, on-shore and off-shore exploration and production techniques. Future petroleum provinces, particularly in off-shore region; case histories of selected oil fields.

**424 Tectonics of Continental Margins.** Deformation history of selected continental margins and shallow seas. Methods of investigation, geophysical drilling and dredging. Role of ocean-floor spreading, ocean trenches, and large ocean-floor faults in tectonics of continental margins.

**426 Regional Tectonics.** Growth of mountains as illustrated by history, composition, deformation style of selected mountain ranges. Examination of mountain building in relation to rigid plate tectonics, particularly ocean trenches. Discussion of volcanism and plutonism as mountain-building processes.

**436 Rock Deformation.** Review of stress analysis and behavior of materials, both rock mass and sample. Fundamentals of deformation pertaining to crustal rocks and problems of geological sciences.

**461 Mineral Deposits: Metals.** Description, origin, distribution, economic significance of principal types of metallic ore deposits. Principles and processes involved in formation of metallic ore deposits within context of their geologic environments. Megascopic and microscopic identification of principal opaque ore minerals; hand-sample and microscopic study of representative ore and rock suites from various mining districts.

**462 Mineral Deposits: Nonmetals.** Properties, occurrence, associations, distribution, economic utilization of the industrial minerals and rocks.

**471 Invertebrate Paleontology.** Paleobiology and classification of important fossil invertebrates.

**485 Physics of the Earth I.** Rotation and figure of the earth, gravitational field, seismology, geomagnetism, creep and anelasticity, radioactivity, earth's internal heat, continental drift, mantle convection.

**486 Physics of the Earth II.** Composition and structure of the atmosphere and oceans, radiative balance, heat budget, dynamics of the oceans and atmosphere, tides, geostrophic motions and thermal wind, Rossby waves and cyclogenesis, internal waves and seiches.

**488 Introduction to Geophysical Prospecting.** Primarily for geologists and engineers covering prospecting principles, instrumentation, operational procedures, interpretation techniques in geophysical exploration for oil, gas, minerals. Emphasis on seismic reflection, seismic refraction, gravity, magnetic methods of exploration.

**632 Exploration Geology.** Methods of exploration and appraisal of geologic data from both field and laboratory investigations. Assessment of environmental geology and presentation of direct and indirect information for professional purposes.

**633 Environmental-Engineering Geology: Theory.** Advanced study of physical phenomena and rock properties of special importance from planning through operation stages of engineering works and man's environment; includes underground fluids, subsidence, gravity movement, seismicity, geomechanics and stresses, rock mechanics, weathering, geologic materials of construction. Analysis of geologic problems encountered in practice; predicting influence of natural and man-made environmental factors.

**635 Engineering Geology: Practice.** Application of geological principles in planning-design, construction, operation of engineering works. Case histories, analysis, evaluation of physical environmental factors, remedial treatment, reports.

**642 Glacial and Pleistocene Geology.** Glacial processes and deposits and stratigraphy of Pleistocene.

**673 Stratigraphy.** Principles of stratigraphy, developed by detailed study of selected American and European systemic examples.

**681 Geotectonics.** Theories of orogeny; ocean and continent evolution. Kinematics of lithosphere plates. Rock-time assemblages of modern oceans and continental margins, and analogs in ancient orogenic belts. Time-space reconstructions of specific regions. Problems of dynamic mechanisms — corollaries and evidence from crustal features.

**687 Seismology.** Theories of generation and propagation of elastic waves in earth. Derivation of structure of earth and mechanisms of earthquakes from seismological observations.

**688 Gravity, Geomagnetism, and Heat Flow.** Measurement and mathematical description of gravitational and magnetic fields of earth. Heat flow. Gravitational, magnetic, heat flow anomalies and structure of earth; theories of origin of geomagnetic field. Selected advanced topics.

**690 Seminars and Special Work.** Advanced work on original investigations in geological sciences.

690-a Structural geology, sedimentation, tectonics.

690-b Petrology and geochemistry of metamorphic and igneous rocks, associated metallic minerals.

690-c Coastal geomorphology and Pleistocene geology.

690-d Environmental-engineering geology, geomechanics, hydrogeology.

690-e Geophysics, seismology, gravity, magnetism, heat flow, geotectonics.

690-f Invertebrate paleontology and paleoecology.

690-g Mineral deposits and resources.

690-h Environmental problems.

690-i Marine geology.

690-j Plate tectonics and geology.

## Field Courses

**602 Introductory Field Geology.** Techniques of field mapping learned by examining selective localities in southern New York and vicinity. Techniques include use of Brunton compass, detailed field descriptions of various rock types, identification and field use of fossils, description of land forms. Students make detailed and regional geologic maps, construct cross sections and columnar sections, make observations on environment of deposition or conditions of emplacement of rocks and describe their subsequent geologic history.

## Germanic Studies

### 402 History of the German Language.

**405-406 Introduction to Medieval Literature.** For students with no previous knowledge of Middle High German. Survey of most outstanding works of Court Epic, Heroic, Epic, Minnesang. Emphasis on thorough understanding of Middle High German language.

**407 German for Teachers.** Methods of teaching the language based on contrastive study of structures of English and German. Extensive outside reading, reports on textbooks, discussion of various teaching aids and realia.

**408 Linguistic Structure of German.** Descriptive analysis of present-day German; emphasis on phonetics, morphology, syntax.

### 410 Topics in Classicism and Romanticism.

### 411 Modern Dramatists.

### 413-414 Topics in Modern German Literature I and II.

**417-418 The Great Moments of German Literature.** Recommended for graduate students, whether majoring in German or not, who wish to acquire overall view of whole range of German literature from earliest texts to present day. Prerequisite: reading knowledge of German. Lectures aim at characterization of temper of a period or essential nature of a certain writer. Discussion periods concentrate on individual works illustrative of topics of lectures.

### 421 Germanic Mythology.

### 424 Old Norse Sagas in English Translation.

### 601 Introduction to Germanic Linguistics.

### 602 Gothic.

### 603-604 Old Saxon, Old High German, Old Low Franconian, Old Frisian.

**609-610 Old Norse.** Grammar and phonological history of the language. Student introduced to representative selections from literature of Old Icelandic.

### 611 Heroic Poetry and Heroic Legend in Icelandic.

### 612 Icelandic Family Sagas.

### 613 Seminar in Old Norse Language and Literature.

### 614 Skaldic Poetry.

**621-622 Computer Methods in Germanic Studies.** Use of computer in analyzing Germanic texts, including modern Germanic languages. Practical experience in using text processing programs.

**623 Middle High German Literature I.** Topic: The courtly epic. Emphasis on Wolfram von Eschenbach.

**624 Middle High German Literature II.** Topic: The Nibelungen legend and its literary manifestations.

### 625 German Literature of the late Middle Ages.

### 626 Sixteenth-Century German Literature.

### 627 Seventeenth-Century German Literature.

### 630 Topics in Eighteenth-Century Literature other than Goethe.

### 631-632 Topics in Goethe.

### 633 German Romanticism.

### 635-636 Topics in Nineteenth-Century German Literature.

### 638-639 Topics in Twentieth-Century German Literature.

### 640 History and Methods of Modern German Literary Criticism.

### 641 The Postwar German Novel.

### 699 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.

### 710 Seminars in Germanic Linguistics.

### 720 Seminar in Comparative Germanic Linguistics.

**730 Seminar in Germanic Linguistics.** Selected topics including history, structure, dialects of modern German.

**740 Seminar in Dutch Linguistics.** Selected topics: history, structure, dialects of modern Dutch.

### 741-742 Seminar in Scandinavian Linguistics.

Selected topics: history, structure, dialects of selected Scandinavian languages.

### 753-754 Seminar in German Literature.

See also courses listed under the Field of Comparative Literature and the Field of History.

## Government

### American Politics

#### 603 (503) Field Seminar in American Politics.

Introduction to some major research areas in American politics; parties and elections; legislative behavior; leadership (especially presidency); judicial behavior; comparative state politics, policy analysis. Reading illustrates a variety of analytical approaches and techniques. Short critical and synthetic papers assigned.

#### 611 (512) Urban Politics and Public Policy.

Provides students with background in general field of gaming and simulation; special emphasis on application of these tools to urban policy research and teaching. Provides opportunity to participate in research project in development of an urban

simulation game designed for undergraduate teaching.

**612 (513) The Presidency and Federal Executive Branch.** Seminar analyzes research techniques and major topics in recent study of the presidency. Emphasis on public policy consequences, including institutionalized presidency, public opinion, congressional-executive relations, recurrent constitutional issues.

**613 (514) American Urban Politics.** Seminar to familiarize student with important perspectives and literature on problems of governing American urban areas. Extensive reading, discussion of main theoretical approaches, short synthetic papers.

**614 Supreme Court, Politics, and the Constitution.**

**615 (520) Public Opinion and Public Policy.** Seminar. Intensive analysis of linkages between public opinion and public policy in context of political system. Specific topics: perception of policies, impact of opinion on public policy formation and implementation, symbolic uses of politics, variation in opinion-policy interaction across different policy areas.

**616 (517) Judicial Behavior.** Primarily a research seminar on theories and methods used in study of judicial behavior. Topics: judicial recruitment, socialization, decision-making, impact. Focus on American judiciary; judiciaries of Europe and Asia also considered.

**617 (523) American Bureaucracy and Public Policy.** Seminar. Intensive introduction to aspects of public bureaucracies most relevant to their policy-making role. Topics: political environment, communication, decision-making, innovation, discretion. Social control bureaucracies with emphasis on problems of bureaucratic discretion and responsiveness to various conceptions of public interest. Case material includes studies of law enforcement and regulatory agencies.

**618 (525) American Political Behavior.** Examination of current research in areas of American politics: political socialization, ideology, political participation, elite recruitment, political behavior in small groups. Both substantive and methodological issues discussed with particular attention to gaps in existing studies and goals of future research.

**619 (526) Political Socialization.** Seminar involves (1) critical analysis of research on American political behavior, (2) design and execution of original research based on existing data. Emphasis on areas of political socialization, public opinion, political participation. Additional areas of interest considered. No previous empirical research experience required.

**620 The Politics of American Economic Life.** Intensive examination of research strategies and selected topics in relationship between business and government. Topics: regulatory politics, economic policy making, political role of giant corporations.

## Comparative Politics

**605 (505) Field Seminar in Comparative Politics.** Critical review of advantages and limitations of comparative inquiry. Theoretical, conceptual, methodological issues involved in comparative research. Examination of various units of comparative inquiry, individuals, groups, institutions, national systems; problems of generalization and validation across cultures and time.

**637 (537) [BPA 509] Political Development and Social Change.** Critical review of present state of study of political development, including analysis in detail of major writers in the field. How the process of increasing social differentiation and of higher levels of economic wealth effect political process. Also, problems of cross-national research and comparison of structural features of developing countries.

**638 (546) European Political Development.** Genesis and evolution of Western European nation-states, analyzed from standpoint of institutional and ideological growth; impact of historical political movements on relations between state and society through development of new forms of mass participation and of elite reconciliation. Western European party system, its changes and its relationship to European society.

**639 (534) Politics of the Soviet Union.**

**640 (535) Problems of Political Succession.**

**641 (542) Politics and Economic Change in Contemporary Europe.**

**642 (543) Politics of Communalism.** Seminar investigates politics of racial, ethnic, religious, linguistic, cultural pluralism. Emphasis on subnational pluralism, implications of communal cleavages for management of various expressions of communal conflict. Focus on relationships between modernization and communal pluralism, but includes manifestation of these phenomena in industrialized societies.

**643 (544) [BPA 561] Comparative Local Politics.** Analysis of how subnational policy processes and political structures relate to national politics. How participation and party activity at local level may or may not influence local policies, and extent to which citizens may or may not exercise policy control. Comparative approach used involving England, France, several developing countries.

**644 (541) Politics of Population.** Politics of population size, composition, distribution, growth examined within specific countries and as factors in international relations. Emphasis on government policies with respect to fertility, mortality, migration, rural-urban distribution. Case studies include United States and other postindustrial societies, various developing countries, international organizations such as World Bank.

**645 (547) Politics of China.** Seminar on post-1949 Chinese political system. Problems and tensions confronting the regime. Each student prepares a

substantial research paper on some aspect of contemporary Chinese politics.

**646 (548) Comparative Communism.**

**647 (550) [Anthro. 628] Politics and Anthropology.** Discussion of cultural matrices of traditional and posttraditional societies in Southeast Asia. Emphasis on forms of consciousness: their impact on functioning of political institutions and styles of leadership, and their relationship to goals and structures of social movements.

**648 (560) Political Economics of Change: Rural Development.** Seminar organized to serve substantive and analytical purposes. Substantive focus is on economic, social, political change in Third World countries and particularly on strategies for rural development. Analytical approach used is a new version of political economy which integrates economic, social, political factors into a common framework. Seminar intended to contribute to development of a social science useful for achieving public purposes and capable of informing political choices, with special reference to the Third World.

**649 (576) Political Modernization and Japan.** Seminar will be twofold: first, the relevance of the various theoretical analyses of modernization in understanding Japan between the late Tokugawa Period and World War II and; second, the implications of the concrete Japanese experience both for abstract theory and for nation-states now undergoing modernization. Problems such as nationalism, political organization, participation, military organization, militarism.

**650 (540) Government and Politics of Latin America.** Seminar conducted in conjunction with undergraduate course Gov. 340. Elucidation and critique of common conceptions of Latin American politics, as presented in lectures and readings of 340. Seminar members "test" these and alternative conceptions against evidence found in well-defined episodes of Latin American politics.

**651 (547) Readings from Mao Tse-tung.** Prerequisites: two years of Chinese or consent of instructor. Seminar. Articles written in Chinese by Mao read and analyzed linguistically and politically.

**652 (644) Political Problems of Southeast Asia.** Focus is on one of several major recent or contemporary political problems confronting states of Southeast Asia: national coherence; political stability versus socioeconomic progress and distributive justice; Buddhism and/or Islam as political forces; political residua of colonial rule; impact of outside powers on indigenous politics.

**653 (541) Comparative Political Parties.**

**654 (547) Culture and the Mass Line in China.** Origins of Great Proletarian Cultural Revolution. Investigation along two related lines: (1) impact of culture and "superstructure" on Chinese revolutionary process and Chinese society as a whole since mid-1960s; (2) character of tensions and other relationships which developed between party

leadership and spontaneous mass action during the Cultural Revolution.

**735 Research Seminar on Strategies of Rural Development.** This seminar presumes that students have broad knowledge of rural development issues and cases and wish to pursue serious comparative research on rural development strategies and policies. Cross-disciplinary analysis and more comprehensive analytical framework developed as preparation for field research.

**International Relations**

**606 (509) Field Seminar in International Relations.** General survey of literature and propositions of international relations field. Criteria developed for judging theoretical propositions; these applied to major findings. Participants expected to do extensive reading in literature and engage in certain research activities.

**680 (571) Quantitative International Politics.** Recent quantitative approaches to analysis of international politics briefly surveyed. Individual research projects on a specific problem in international politics such as relations between public opinion and foreign policy or definition of power.

**681 (572) Transnational Politics.** Study of interaction between governments and transnational actors in economics and political contexts. Character of transnational relations and organizations; particular issue areas.

**682 (583) Communist China in International Politics.** Analysis of major problem areas in the C.P.R.'s external relations, with special emphasis on Chinese foreign policy strategy and doctrine.

**683 (561) [BPA 640] Science, Technology and International Relations.** Examination of issues involved in formulation and implementation of national science and technology policies in less developed countries and processes of transferring physical and managerial technologies between industrialized and less industrialized countries. Choices of technologies, instruments and channels of transfer, process of technological adaptation, development of scientific and technological institutions, implications of science policy and technology transfer for economic growth, social equity, political integration, international cooperation.

**684 (568) International Strategy.** Doctrines of deterrence and defense, particularly their interaction in American policy since 1945. Relationship between doctrine and the type of international system: bipolar or multipolar. Other means of equilibration in the international system.

**685 (574) Analysis of Foreign Policy.** Analytical survey of some principal ways in which foreign policy may be studied, including both efforts at generalization and case studies.

**686 (575) International Organization and World Politics.**

**687 (577) International Relations of Asia.**

American Southeast Asian policies: genesis, character, impact, long-term consequences. Elements involved in formation of American policies toward Southeast Asia by several postwar administrations (Truman through Nixon) including international factors and considerations of American domestic politics. Ways in which these policies have been applied and their influence on political forces within the countries of Southeast Asia.

**688 (578) [Econ. 648] United States' Presence in Latin America.** Interdisciplinary seminar. Impact which North American institutions—cultural, economic, political—have upon contemporary Latin American societies. Some readings in Spanish.

**689 International Integration.****Political Thought****607 (507) Field Seminar in Political Thought.**

Introduction to political theory through reading of selected classics in political thought from Plato to Marx.

**665 (528) American Political Thought.** Four major areas in American political thought: Puritan notions of authority and citizenship; political thought of revolutionary and early constitutional period; "progressive" scholarship; contemporary American political science.

**666 (529) Political Philosophy of Nietzsche.** Close textual analysis of *Thus Spoke Zarathustra* and readings in other texts by Nietzsche.

**667 (555) Philosophical Foundations of Contemporary Politics.** Seminar. Relationship (if any) between traditional concerns of political philosophy and current policy issues in the United States. Topics: justice, freedom, equality, obedience, on one hand, and income distribution, violence, censorship, repression, minority rights, disobeying law, on the other.

**668 (556) Legal Theories of Liberalism.**

Relationships between economic, psychological, political, religious elements of law and theories of punishment in Hobbes, Locke, Hume, Bentham. Relationship of common law reasoning to conservative political philosophy in England. Problem of separation of law and morals in Bentham, Austin and Hart.

**669 (558) Nineteenth-Century Social Thought.**

Seminar. Some problems of democratic theory and political analysis. Selections from works of Tocqueville, Marx, Bentham, J. S. Mill, others.

**670 (559) Twentieth-Century Social Thought.**

Examination of several basic normative concepts in political philosophy from modern analytical perspective. Topics: justice, rights, liberty, obligation, responsibility.

**671 Anarchism.**

**672 The Enlightenment: Political and Social Thought in the Age of Reason.**

**Public Policy****604 (510) Field Seminar in Public Policy.**

**626 [BPA 559] Science, Technology, and Public Policy.** Examination of science policy and policy-making in the United States. Consideration of: scientific and technological manpower; institutional framework for science policy-making in private and public sector; science policy process in public and private sector; science policy as political issue. Emphasis on case studies of situations where science and technology are applied to social problems including, for example, energy policies, aerospace program decisions, nutrition, contraception.

**627 Comparative Science Policy.**

**628 (511) Workshop in Public Policy.** Analysis and criticism of public policies and related issues of theory, method, application. First semester: locating the best research problems and presenting them as prospectus designs, plans. Second semester: revolves around presentation of completed draft.

**Methodology****601 (501) Field Seminar in Political Analysis.**

Introduction to principles of research design methods of data collection, analysis. Emphasis on alternative types of data collection and some basic techniques, rather than complex statistical analysis of existing data.

**602 (502) Field Seminar in Political Methodology.**

Philosophy and methodology of hypothesis testing in political science as contrasted with other sciences. Attention to general problems of research design and hypothesis formulation, with intent of laying solid foundation for use of quantitative and statistical methods for political analysis.

**696 Mathematics and Politics.****697 (584) [Psych. 575] Personality and Politics.****698 Culture and Politics.****699 The Methodology of Policy Evaluation.****History****American History**

**311-312 The Structure of American Political History.**

**313-314 History of American Foreign Relations.**

**316-317 American Cultural and Intellectual History.**

**318 American Constitutional Development.**

**321 The Origins of American Civilization.**

**325 Age of the American Revolution, 1763-1815.**

330 The United States in the Middle Period, 1815-50.

331 The American Civil War and Reconstruction.

334 Nationalism and Nostalgia in American Life, 1870-1930.

340 Recent American History, 1917-41.

341 Recent American History, 1941 to the Present.

345 The Modernization of the American Mind.

346 The Irrational and the American Mind.

411 Problems in American Political History.

414 Motivations of American Foreign Policy.

422 The American Enlightenment.

613-614 Seminar in the History of American Foreign Relations.

615-616 Seminar in American Cultural and Intellectual History.

621-622 Seminar in Early American History.

633-634 Seminar in Nineteenth-Century American History.

640-641 Seminar in Recent American History.

## Asian History

393 History of Chinese Civilization prior to the Nineteenth Century.

394 History of Chinese Civilization: Nineteenth and Twentieth Centuries.

395 Southeast Asian History to the Fourteenth Century.

396 Southeast Asian History from the Fifteenth Century.

492 The Medieval Chinese World.

588-589 The Historiography of Southeast Asia.

691 Chinese Historiography and Source Materials.

693-694 Modernization of China.

791-792 Seminar in Medieval Chinese History.

793-794 Seminar in Modern Chinese History.

795-796 Seminar in Southeast Asian History.

## Ancient European History

261-262 Classical Antiquity.

461 The Roman Revolution, 146-44 B.C.

462 Early Imperial Rome, 44 B.C.-A.D. 70.

463 Classical Greece, 510-404 B.C.

464 Classical Greece, 404-338 B.C.

661-662 Seminar in Ancient Classical History.

## Medieval and Early Modern European History

263-264 Medieval History.

350-351 Europe in the Age of the Renaissance, Reformation, and Counter-Reformation.

365 Medieval Culture, 400-1150.

366 Medieval Culture, 1150-1300.

367 Church and State During the Middle Ages.

469 Catherine de Medici and the French Wars of Religion.

470 The Spanish Empire and the Revolt of the Netherlands.

663 Seminar in Medieval History.

664-665 Seminar in Latin Paleography.

666-667 Seminar in Medieval History.

## Modern European History

253-254 Survey of Russian History.

257 English History from Anglo-Saxon Times to the Revolution of 1688.

258 English History from the Revolution of 1688 to the Present.

351-352 Modern German History.

353-354 European Intellectual History in the Nineteenth and Twentieth Centuries.

355 The Old Regime, France in the Seventeenth and Eighteenth Centuries.

356 The Era of the French Revolution and Napoleon.

357 English Constitutional History I: To 1485.

358 English Constitutional History II: Since 1485.

370 The Age of Enlightenment.

371 History of England under the Tudors and Stuarts.

374 War, Trade, and Empire, 1585-1815.

375 England since 1870.

377 Intellectual Currents of the Seventeenth Century.

378-379 Europe from the End of the Ancient Regime.

405 Population and History.

475 The English Civil War, 1640-60.

477 The Politics of the Enlightenment.

## History of Science

311-312 Science in Western Civilization.

385-386 Problems in the History of Biology.

**680-681 Seminar in the History of Science during the Nineteenth and Twentieth Centuries.**

**685 Seminar in the History of Early Modern Science.**

**Latin American History**

**210 The Colonial Experience in Latin America.**

**211 Latin American History in the Nineteenth and Twentieth Centuries.**

**306 Quantitative Approaches in History.**

**703-704 Supervised Reading.**

**History of Architecture and Urban Development**

**340 (430) The Ancient Near East.** Architecture of oldest historic civilizations associated with Western tradition, with emphasis on Egypt and Mesopotamia.

**341 (431) The Classical World.** Architecture of ancient Mediterranean civilizations, especially Greece and Rome.

**344 (434) Islamic Architecture.**

**Architecture 345 (435) UPD 403 (602) Architecture and Planning in the Orient.** Introduction to evolution of architecture and urbanization in India, China, Thailand, Cambodia, Japan.

**346 (436) The Renaissance.** European architecture of fifteenth and sixteenth centuries.

**347 (437) The Baroque.** European architecture of seventeenth and eighteenth centuries.

**348 (438) American Architecture.** Building in U.S. from colonial times, with emphasis on nineteenth and twentieth centuries.

**439 (439) Modern European Architecture.** Survey of nineteenth- and twentieth-century architecture in Europe.

**442 (451-452) Historical Seminars in Architecture.** Qualified students prepare papers on problems relating to design or architecture, using historical evidence as basis.

**445 (455) Special Investigations in the History of Architecture.**

**540 (460-461) Introduction to Architectural Aspects of Archaeological Field Work.** For architects, archaeologists, laymen. Investigation of architectural techniques used in archaeology.

**541 (484) Practice in Architectural Aspects of Archaeological Field Work.** Supervised work in the field on excavation, interpretation, or restoration of historic architecture.

**Architecture 542 (462) UPD 404 (601) Methods of Archival Research.** Examination of methods of archival research in history of architecture and urban development, using manuscripts, drawings,

correspondence, documents in Department of Manuscripts and University Archives.

**544 (464) Case Studies in Preservation Planning.** Review and critique of preservation planning projects selected to indicate range of current approaches.

**Architecture 545 (465) PPRA 844 (644) Design and Conservation.** Introduction to methods of utilizing existing cultural and aesthetic resources in planning and design of regions and cities.

**Architecture 546 (466) PPRA 845 (645) Documentation for Preservation Planning.** Methods of collecting, recording, processing, analyzing architectural and cultural survey materials.

**548 (488) Problems in Modern Architecture.**

**640 (470) Seminar in Architecture of the Ancient Near East.** Problems in Near Eastern architectural history.

**641 (471) Seminar in Architecture of the Classical World.** Problems in Greek and Roman architectural history.

**643 (473) Seminar in Medieval Art and Architecture.**

**646 (476) Seminar in Renaissance Architecture.** Historical problems of European architecture of fifteenth and sixteenth centuries.

**647 (477) Seminar in Baroque Architecture.** Historical problems in European architecture of seventeenth and eighteenth centuries.

**648 (478) Seminar in the History of American Architecture.** Investigation by means of reading, lectures, reports of historical problems in architecture of nineteenth and twentieth centuries in U.S.

**649 (479) Seminar in the History of Modern Architecture.** Problems in modern art and architecture.

**740 (467-468) Informal Study in the History of Architecture.**

**840 (491-492) Thesis in History of Architecture.** Independent research by candidates for the master's degree.

**898 (PPRA) Thesis in History of Urban Development.** Independent research by candidates for the master's degree.

**940 (497-498) Dissertation in History of Architecture.** Independent research by candidates for the Ph.D. degree.

**998 (PPRA 799) Dissertation in History of Urban Development.** Advanced independent research by candidates for the Ph.D. degree.

**Planning History**

The following courses carry Urban Planning and Development numbers.

**401-501 (UPD 400-500) Historical Development of the World's Cities I.** Historical methods and research techniques; case studies and aesthetic

evaluation; urban revolution; classical societies; medieval urbanism; the Renaissance and the baroque in Europe; colonization and North America.

**402-502 (UPD 401-501) Historical Development of the World's Cities II.** Introduction; social, philanthropic, 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.

**405 (UPD 604) The History of Colonial Planning.** Colonial city planning and civic design in Africa, America, Asia, Australasia.

**406 (UPD 605) Introduction to the History of Landscape Architecture and Design.** Classical landscape in Mediterranean area and Middle East; Islamic Byzantine tradition; medieval cityscape and agrarian system; Renaissance; landscape of gardens in Persia, India, China, Thailand, Japan. Victorians; landscape in North America; colonial landscape; twentieth century; horticulture and techniques; landscape in contemporary planning and architecture.

**504 (UPD 603) Seminar in the History of American City Planning.**

**641 (UPD 640) Seminar in Urban Design.** Investigation of historical and current thought on visual aspects of cities, including evaluation of technological and cultural influences on urban design, perception of urban form, relationships between contemporary city planning process and visual form in cities.

**909 (UPD 709) Informal Study in the Historical Development of Urban Areas.**

## History of Art and Archaeology

For descriptions of the courses currently given, see the most recent edition of the *Announcement of the College of Arts and Sciences*.

### History of Art

**314 Primitive Art.**

**315 Pre-Columbian Art.**

**322 Arts of the Roman Empire.**

**323 Painting in the Greek and Roman World.**

**324 Architecture in the Greek and Roman World.**

**332 Architecture of the Middle Ages.**

**333 Early Medieval Art and Architecture.**

**334 Romanesque Art and Architecture.**

**335 Gothic Art and Architecture.**

**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.**

**349 Italian Renaissance Architecture.**

**354 Dutch Painting of the Seventeenth Century.**

**355 French Art of the Sixteenth and Seventeenth Centuries.**

**357 European Art of the Eighteenth Century.**

**363 Modern Painting.**

**367 Modern Architecture.**

**378 American Architecture, the City, and American Thought: 1850-1950.**

**383 Art of China.**

**384 Art of Japan.**

**385 Chinese Painting.**

**386 Studies in Indian and Southeast Asian Art.**

**392 Latin American Art.**

**411 Techniques and Materials: Painting.**

**412 Techniques and Materials: Graphics.**

**413 Books, Prints, and the Graphic Image.**

**414 Form, Content, Technique in the Mass Media.**

**415 Seminar in Pre-Columbian Art and Archaeology.**

**421 The History of Art Criticism.**

**431 Greek Sculpture.**

**448 Mannerism and the Early Baroque in Italy.**

**449 Studies in Italian Renaissance Art.**

**452 Studies in English Art.**

**458 Classic and Romantic Art.**

**462 Art and Technology: 1850-1950.**

**472 Romanticism in Painting.**

**474 American Crafts and Decorative Arts of the Colonial Period and Early Nineteenth Century.**

**481 Masters of Japanese Prints.**

**482 Ceramic Art of Asia.**

**483 Studies in Buddhist Art.**

**488 Traditional Arts in Southeast Asia.**

**510 Seminar in Latin American Art.**

**531 Problems in Medieval Art and Architecture.**

**564 Problems in Twentieth-Century Art.**

**565 Problems in Modern Art and Architecture.**

- 580 Problems in Asian Art.
- 584 Problems in Chinese Art.
- 586 Studies in Chinese Painting.
- 591-592 Supervised Reading.
- 595 Methodology Seminar.
- 596 Problems of Art Criticism.

### Archaeology

Students who are interested in archaeology are directed especially to History of Art 314, 315, 415, 488, and 531, 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.

- 424 Numismatics.
- 523 Ceramics.

### Hotel Administration

For descriptions of the following courses, see the *Announcement of the School of Hotel Administration*.

#### Management

- HA 214 Hotel Computing Applications.
- HA 311 Union-Management Relations.
- HA 313 Development of Training Programs.
- HA 315 Seminar in Organizational Behavior and Administration.
- HA 316 Seminar in Franchising.
- HA 317 Advertising and Public Relations.
- HA 318 The Psychology of Advertising.
- HA 412 Management Principles.
- HA 413 Seminar in Advertising and Public Relations.
- HA 414 Seminar in Marketing.
- HA 415 Seminar in Hospitality Simulation Exercises.
- HA 519 Marketing Management.
- HA 710 Graduate Directed Hotel Studies in Management.
- HA 712 Graduate Seminar on Marketing.

#### Financial Management

- HA 322 Investment Management.
- HA 323 Financial Analysis and Planning.
- HA 324 Financial Analysis and Planning.
- HA 327 Financial and Tax Aspects of the Leisure Time Industries.

HA 326 Introduction to Statistical Analysis and Inference.

HA 421 Internal Control in Hotels.

HA 720 Graduate Directed Studies in Financial Management.

HA 721 Graduate Accounting and Financial Management I.

HA 722 Graduate Financial Management II.

#### Food and Beverage Management

- HA 331 Survey of Convenience Food.
- HA 332 International Hotel Cuisine.
- HA 333 Restaurant Management.
- HA 334 Beverage Management.
- HA 335 Menu Planning.
- HA 336 Managerial Aspects of Purchasing.
- HA 337 Specialty Food Systems.
- HA 338 Special Problems in Food.
- HA 431 Educational Techniques in Food Systems.
- HA 730 Graduate Directed Studies in Food and Beverage Management.
- HA 732 Introduction to Food Preparation for Graduate Students.
- HA 733 Advanced Management of Food Production Systems.
- HA 734 Restaurant Management Systems.

#### Administration

- HA 343 Law of Business: Contracts, Bailments, and Agency.
- HA 344 Law as Related to Innkeeping.
- HA 345 Law of Business: Business Organization, Partnerships, and Corporations.
- HA 346 General Survey of Real Estate.
- HA 441 Seminar in Real Estate.
- HA 442 Orientation in Safety of Personnel and Property.
- HA 541 General Insurance.
- HA 542 Law and the Woman Employee.
- HA 740 Graduate Directed Studies in Hotel Administration.

#### Properties Management

- HA 353 Food Facilities Programming, Planning, and Design.
- HA 354 Advanced Food Facilities Engineering.
- HA 452 Seminar in Hotel Guest Room Design.

- HA 453 Seminar In Environmental Control.
- HA 454 Seminar In Hotel Planning.
- HA 455 Seminar In Restaurant Planning.
- HA 456 Seminar In Destination Resort Planning.
- HA 457 Food Facilities Equipment, Layout, and Design.
- HA 458 Food Facilities for Convenience Foods.
- HA 750 Graduate Directed Studies in Properties Management.
- HA 751 Graphics, Design, and Construction.
- HA 752 Environmental Systems.

### Managerial Communications

- HA 761 Graduate Directed Studies in Managerial Communications.

### Science

- HA 770 Graduate Directed Studies In Food Science.

## Human Development and Family Studies

- 323 Cognitive Processes.
- 324 Piaget's Theory of Cognitive Development.
- 325 Exceptional Children.
- 329 Human Sexuality and Interpersonal Relationships.
- 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.
- 350 Case Studies of Intrafamily Interaction.
- 352 Contemporary Family Forms.
- 358 Theories of the Marital Dyad.
- 360 Personality Development In Childhood.
- 362 The Family, Society, and the Individual.
- 372 Perspectives on Poverty.
- 374 Behavior and Development In Infancy.
- 397 Experimental Child Psychology.
- 405 Theories of Child Development.
- 464 Selected Problems In Emotional and Intellectual Deviations In Children.
- 465 Innovative Programs of Parent Intervention and Community Action.

- 600 Special Problems for Graduate Students.
- 608 Seminar In Theories of Intelligence.
- 614 Clinical Deviations In Intellectual and Sensory-Motor Development.
- 620 Issues In Developmental Psychology.
- 622 Seminar In Cognitive Development.
- 623 Seminar In Cognitive Processes.
- 660 Seminar In Psychopathology.
- 662 The Family, Society and the Individual.
- 664 Family and Kinship.
- 674 Seminar In Infant Behavior and Development.
- 680 Seminar on Adolescent Behavior.
- 695 A Process Approach to Early Education.
- 699 Master's Thesis and Research.
- 709 Seminar In Projective Techniques.
- 711 Evaluation Practicum: Study of the Individual Personality, Deviant and Normal.
- 713 Individual Intelligence Test Procedures.
- 715 The Development of Human Behavior.
- 721 Seminar In the Development of Social Behavior.
- 722 The Nature of Subjective Reality.
- 723 Seminar In the Development of Language.
- 760 Personality Development In Childhood.
- 762 Socialization In Sociological Perspective.
- 799 Doctor's Thesis and Research.

## Human Nutrition and Food

**441 Nutrition and Disease.** Study of physiological and biochemical anomalies in certain diseases and principles underlying nutritional therapy. Independent survey of technical literature in this field. Some laboratory work on nutrient composition of food, physiological response to different diets, 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 improvement of man's health; evaluation of federal, state, community programs focused on improving man's nutrition. Laboratory work includes (a) developing materials for field studies and evaluation, (b) projects and field trips in nearby communities. Field experiences selected and developed to expose students to food and nutrition problems of man over his entire life span. Estimated cost \$5.

**446 Physicochemical Aspects of Food.** 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 color, flavor, texture of natural and processed foods.

**447 Physicochemical Aspects of Food, Laboratory.**

Laboratory experiments designed to illustrate effect of varying ingredients and treatment on quality characteristics of food products. Objective testing methods used to determine food quality characteristics.

**448 Physicochemical Aspects of Food, Laboratory.**

Laboratory experiments designed to illustrate (a) physicochemical behavior of colloidal systems; (b) chemical reactions of some food components; (c) effects of temperature, pH, moisture, inorganic salts and enzymes on physicochemical changes in natural foods, food components, food mixtures.

**456 Experimental Food Methods.** Application of scientific method in design and performance of experimental food problems and in interpretation and evaluation of results. Evaluation of use of instruments, chemical, sensory methods in measurement of food properties. Independent laboratory problems.

**478 Volume Food Production.** Menu planning and evaluation relative to production capacity, cost, 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 arranged in a food service unit on campus, in health-care facilities, other community facilities for students to become familiar with quantity production and food service in an operating situation.

**600 Special Problems for Graduate Students.**

**601-604 Advanced Nutrition Series.** See listing under Field of Nutrition.

**612 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.

**614 Readings in Nutrition.** Critical review of literature on selected topics in field of nutrition. Emphasis on human nutrition. Topics changed each term so the course may be repeated for credit with permission of the instructor.

**615 Seminar in Ecology of Human Nutrition and Food.** Introduction to food and nutrition for graduate students who have had limited or no work in this area. Seminar utilizes lecture and discussion of 115A as basis for supplementary readings and critical review of research on selected nutritional problems.

**616 Readings in Food.** Critical review of selected topics in current literature. Emphasis on experimental data and basic scientific principles underlying modern theory and practice relative to food quality.

Topics changed each term. Course may be repeated for credit.

**624 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; evaluation. Laboratory includes planning and management of a metabolic study, collection and analyses of blood, urine, feces.

**625 Seminar in a Sociocultural Approach to Food and Nutrition.**

Seminar critically reviews selected topics given to development of a research proposal utilizing sociological conceptual frameworks and methods and techniques as applied to nutritional data.

**626 Special Topics in Food.**

Study of polysaccharides of importance in food products including starches, starch derivatives, pectins, other neutral and acidic carbohydrate polymers. Topics: 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, their role in food products. May be repeated for credit with permission of instructor.

**627 Special Topics in Food.** Enzymes and enzymatic changes in foods. May be repeated for credit with permission of instructor.

**645 Food Supply and Human Nutrition.**

Compilation of scientific literature on selected topics dealing with nutritional implications of changes in man's foods. Evaluation of literature relative to answering practical questions raised by lay public and research needed to answer such questions.

**678 Data Processing Applied to Dietary Department Administration.**

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, the scheduling of departmental resources as related to automatic data processing.

**688 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.

**705 Seminar in Human Nutrition and Food.** Fall term: primary emphasis on nutrition. Spring: food science.

**899 Master's Thesis and Research.**

**999 Doctoral Thesis and Research.**

**Graduate School of Nutrition 580 International Nutrition Problems, Policy, and Programs.** Review of food and nutrition problems, policy, programs especially as they relate to developing countries. Emphasis on need to coordinate efforts of various government departments including those of

agriculture, education, economics, health, community development.

**Graduate School of Nutrition 620 General Nutrition.** Offered to students whose principal academic training has been in a field other than nutrition. Designed to meet their need for a basic but intensive introduction to principles, history, application of nutrition.

**Graduate School of Nutrition 650 Clinical and Public Health Nutrition.** Designed to familiarize students with some applications of nutrition to clinical and public health problems.

## Industrial and Labor Relations

### Collective Bargaining, Labor Law, and Labor Movements

**600 Collective Bargaining I.** Comprehensive study of collective bargaining. Philosophy, structures, process of negotiations, administration of agreements. Also, problems of handling and settling industrial controversy, various substantive issues, important developments and trends in collective bargaining.

**601 Collective Bargaining II.** Detailed study of contract making and administration; recent trends and problems in collective bargaining. Several representative industries, and prevailing agreements and case problems studied. Major research paper usually required.

**602 Arbitration.** Study of place and function of arbitration in the field of labor-management relations, including analysis of principles and practices, law of arbitration, preparation of briefs or oral presentation, work of arbitrator, umpire, impartial chairman.

**603 Governmental Adjustment of Labor Disputes.** Study of particular problems of role of government in adjustment of labor disputes in public and private sector. Investigation and analysis of various dispute settlement techniques commonly used and investigation of particular governmental agencies and their operations, including federal, state, municipal agencies.

**604 Readings in the Literature of American Radicalism and Dissent.** Different historical aspect of American radicalism and dissent each term. Range of topics and writers: *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; *women's rights*, Fuller, Stanton, and Anthony.

**605 Readings in the History of Industrial Relations in the United States.** Seminar covering, intensively and in historical sequence, key documents, studies, legislative investigations, memoirs concerning American industrial relations systems. Designed to aid students in orienting themselves systematically and thoroughly in the field. Authors and reports: Thompson, Commons, Ware, Ulman, the Hewitt and Blair hearings, U.S. Industrial Commission, Taft, Brissenden, U.S. Commission on Industrial Relations, Glocker, Barnett, Taylor, Gantt, Follett, Bernstein, Galenson.

**606 Theories of Industrial Relations Systems.** Leading theories concerning origins, forms, organization, administration, aims, functions, methods of industrial relations systems. Marx, Bakunin, Sorel, Lenin, Brentano, the Webbs, Croly, Gramsci, Perlman, Tannenbaum, Guild Socialists, Polanyi, Kerr, Harbison, Dunlop, Myers.

**607 Administrative Tribunals.** Law controlling administrative agencies, including executive departments, in their tasks of carrying out various governmental programs. Procedural safeguards and allocation and control of power in decision making; how to accommodate procedural fairness to efficient accomplishment of legislative purposes. Understanding of principles of exertion of governmental authority and principles of justice that cut across functions of federal, state, local tribunals and their relation with reviewing courts and with legislative and executive bodies.

**608 Black Labor: Directed Research in the History of the Black Worker.** Reviews history of black worker in U.S. through analysis of existing literature of black labor history and through research in source documents from National Archives such as records and correspondence from Division of Negro Economics 1919-21; papers of Lawrence A. Oxley, Chief of the Division of Negro Labor, Bureau of Labor Statistics, 1933-42; papers of Karl Phillips, U.S. Commissioner of Conciliation for Negro Labor, 1925-33; records of the President's Committee on Fair Employment Practice, 1941-45. The black worker in agriculture, in industry, in government; black worker migrations; black workers and organized labor; black workers, discrimination, and the law.

**650 Manpower and Collective Bargaining Problems in the Construction Industry.** Seminar. Supply and demand of construction manpower; Negro and building trades; skilled manpower forecasting and planning; skill requirements; education and training; personnel management policies and practices; wage-price issue; closed shop; featherbedding; jurisdictional disputes; problems of bargaining structure. Individual research required.

**680 Problems in Union Democracy.** Unions considered as an example of private government, and union democracy examined by standards and customary practices in both public and private governments. Elections, self-government by majority, rights of minorities, judicial process including

impartial review, local-national relationships, constituency and representation, the legislative process, executive power and functions. Regulation of private government by the state.

**681 Labor Relations Law.** Advanced course in labor law. Topics: emergency labor disputes, legal problems of labor relations in public employment, labor and antitrust laws, civil rights legislation, rights of individual employees and union members, legal problems of union administration.

**682 Seminar in Labor Relations Law and Legislation.** Legal problems in public employment and other areas of labor relations affecting public interest.

**683 Research Seminar in the History, Administration, and Theories of Industrial Relations in the United States.** Theories of industrial relations, social and political history of workers in urbanizing and industrializing communities, history of ideas which impelled the labor movement, history and government of individual unions and confederations of unions, development of ideas in the management of personnel, comparative studies of American, European, non-European industrial relations systems. Seminar instructor determines areas of study.

**684 Labor and Government from the 1920s to Taft-Hartley.** A historical survey of pre-New Deal, New Deal, World War II, immediate postwar periods, culminating in passage of Taft-Hartley Act. Course traces development and explores nature and effect of government policy on labor welfare and labor relations legislation. Students each select a specific event or problem for research on which they report to the class and prepare a paper.

**685 Collective Bargaining in Public Education.** Seminar. Legal, financial, administrative, educational problems raised by collective bargaining in the public schools. Existing statutes covering employment arrangement in public schools, subject matter and administration of collective agreements, ideological postures of teacher organizations, resolution of negotiating impasses. Individual and group research projects required.

**686 Problems of Labor Relations in Public Employment (Law 523).** Legal problems inherent in superimposition of collective bargaining relationships on existing patterns of public employment, including problems of sovereignty, unit determination, representation procedures, unfair practices, scope of bargaining, impasse procedures, strike against government. Also, civil service systems, government budgeting, restrictions on political activities of public employees (e.g., Hatch Act), loyalty oaths and security programs, other problems peculiar to public employment.

**687 Professionals, White-Collar Workers, and Their Organizations.** Characteristics of professional and clerical workers in the white-collar section of the work force. Problems of professionals, both self-employed and salaried, considered. A variety of professional organizations and of trade unions

studied as responses to collective needs of both groups. Distinctions arising from conditions of public and private employment.

**700 Labor Relations Law and Legislation.** Survey and analysis of labor relations law with examination of extent to which the law protects and regulates concerted action by employees in the labor market. Analysis of legal framework within which collective bargaining takes place. Problems of administration and enforcement of collective agreement and of protecting the individual member-employee rights within the union.

**701 Collective Bargaining.** Analysis with particular emphasis on negotiation process, contract issues of current and future significance. Student research papers.

**702 Problems in Labor Law.** Selected groups of legal problems arising out of labor relations and arbitrations, based on documentary materials including briefs, minutes, court and agency proceedings. Weekly or biweekly written reports.

**703 Research Seminar in the History of Labor in the Nineteenth Century.** Devoted to study of workers in urbanizing and industrializing communities. Research ventures extend across various fields of history, combining traditional labor history with aspects of urban and business history.

**704 Labor Union History and Administration.** Presentation of history of labor in America. Post-Civil War trade union development; analysis of structure and functions of various units of labor organizations, ranging from national federation to local union. Democracy in trade unions and health and welfare plans, and various types of unions, such as those in construction, maritime trades, entertainment, transportation, basic industry.

**799 Directed Studies.** For individual research under direction of a member of faculty.

## Economic and Social Statistics

**710 Economic and Social Statistics.** Nonmathematical course for students in social studies without previous training in statistical method. Technical aspects of statistical analysis and initiative in selecting and applying statistical methods to research problems. Subjects: analysis of frequency distributions, regression and correlation analysis, topics from the area of statistical inference.

**711 Seminar in Statistical Methods.** Planning and analysis of experiments in social sciences. Topics: (a) limitations of experiments in social sciences; (b) appreciation of experimental designs common in social sciences; (c) analysis of designs in (b); (d) use of computer in analysis of these experiments, principally using packaged programs, and some simple programming.

**712 Theory of Sampling.** Development of fundamentals of sampling theory. Attention to recent progress in the field. Occasional illustrations of application of theory.

**799 Directed Studies.** For individual research under the direction of a member of faculty.

## International and Comparative Labor Relations

**630 Seminar in International and Comparative Labor Problems.** Students examine selected problems in the light of international and comparative experience and are expected to prepare, discuss, defend individual research papers. Topics vary from year to year in line with student and faculty interests.

**730 Comparative Industrial Relations Systems I.** Introductory course concerned with history, structure, institutional arrangements, philosophy of labor relations systems of several countries in advanced stages of industrialization. Countries examined include Great Britain, France, Germany, Sweden, others.

**731 Comparative Industrial Relations Systems II.** Comparative review of labor problems in countries in early and intermediate stages of economic development. Survey of development of industrial labor force, evolution of functions of labor organizations, role of government in industrial relations, emergence of different patterns of labor-management relations, problems of employment and wages in relation to economic growth.

**799 Directed Studies.** For individual research under direction of a member of faculty.

## Labor Economics and Income Security

**640 Economics of Manpower.** Various approaches to manpower planning. Topics: labor force development and behavior, occupational choice and occupational mobility, human capital formation, determinants of occupational employment, manpower planning and its relation to economic growth in the U.S. and abroad. Methodologies of projecting and of evaluating manpower programs systematically covered and special topics developed in accordance with student interests.

**641 Comparative Economic Systems: Soviet Russia.** Preparation and discussion of individual papers on selected topics concerning Soviet economy.

**642 Economics of Income Policies.** Examination of economic, political, administrative problems in development and implementation of policies to stabilize and/or control rates of change in wages and prices. Experience in U.S., United Kingdom, various European countries examined.

**740 Labor Economics.** Economic issues in employment and compensation of labor. Topics: labor force growth and composition, structure and functioning of labor markets, unemployment, wage theories, wage levels and structures, economic influence of unions, income distribution, problem of poverty. Required of graduate students majoring or

minoring in labor economics and income security and M.I.L.R. candidates.

**741 Social Security and Protective Labor Legislation.** Fundamental aspects of employee protection and income security. State and federal minimum wage and hour laws, antidiscrimination legislation, laws affecting migratory agricultural labor, employee benefit programs, social insurances, public welfare programs. Underlying causes of legislation, and legislative history, administrative problems and procedures, social and economic impact of legislation. Proposals for amending or modifying existing legislation, including proposals for guaranteed income programs. Normally required of graduate students majoring or minoring in labor economics and income security and required of M.I.L.R. candidates.

**742 Seminar on Investment in Man.** Seminar covers activities which influence future monetary and psychic income by improving resources in people. Investments: schooling, on-the-job training, medical care, migration, search for information on prices and incomes—main emphasis on education and health. Educational planning.

**743 Economics of Poverty.** Causes of and remedies for income inequalities in industrialized economies. Alternative theories of inequality in functional distribution of income—monopolies, rents and quasi-rents, ability, the acquisition of human capital. Relative efficiency of alternative means for remedying these inequalities—countervailing power, taxation, redistribution of social service.

**744-745 Seminar in Labor Economics (Economics 641-642).** Readings and discussion of selected topics in labor economics in the fields of theory, institutions, labor relations, policy.

**799 Directed Studies.** For individual research under the direction of a member of faculty.

**940 Workshop in Labor Economics.** For Ph.D. students writing dissertations. Formulation, design, execution of dissertations. Preliminary plans and portions of completed work presented to workshop for discussion.

## Manpower Studies

**650 Manpower and Collective Bargaining Problems in the Construction Industry.** Seminar examines selected manpower and collective bargaining problems in construction industry: supply and demand of construction manpower, the Negro and building trades, skilled manpower forecasting and planning, skill requirements, education and training, personnel management policies and practices, wage-price issue, closed shop, featherbedding, jurisdictional disputes, problems of bargaining structure, individual research required.

**660 Seminar in Manpower and Organization Management.** One or two specific areas of manpower and organization management selected by student and instructor. Fall: problems of national manpower policy, its implementation at local levels.

Affirmative action and antidiscrimination efforts, or problems of coordinating delivery of services in communities, CAMPS, and other mechanisms for setting policy priorities and evaluating programs. Spring: manpower planning and forecasting, compensation, justice processes, training and development, or other organizational manpower processes. Individual or group research may also focus on external influences or organizational manpower policies, practices, strategies.

**661 Public Policy and Development of Human Resources.** Analysis of need for development of human resources, trends in work force requirements and implications for public policy, role of government and of educational institutions in providing development programs, effectiveness of such programs. Examination of rationale, organization, administration of specific programs, such as apprenticeship; vocational and technical schools; technical institutes; university programs for development of technical, scientific, and managerial skills; foreign technical assistance program. Implications and problems of public support.

**662 Management Training Simulation: Public Policy Issues in Social Agencies.** Seminar conducted through technique of simulation applied to rehabilitation workshop and hospital. Health services management, simulation as an approach to training managers. High degree of involvement of participants in teams to set goals and identify problems and possible solutions—students provided with realistic problem-solving situations involving boards of directors, community resources, public policy issues, state and federal agencies, etc. Variety of aspects of management process and dynamic changes which occur in organizations. Research findings, selected readings, project reports.

**663 History of Contemporary Management Thought.** Critical review of works of major contributors in terms of development of ideas and impacts. Tape recorded interviews with Barnard, Simon, Drucker, Urwick, others.

**664 Management and Leadership Development.** Study of factors affecting growth and development of managers and leaders in industrial and other organizations. Individual and organizational determinants of managerial effectiveness and methods used to influence these. Topics: defining and measuring managerial effectiveness, motivation theory, staffing at managerial level, individual training and development, organization analysis and development. Application of research methods and results to management development problems.

**665 Case Studies In Personnel Administration.** Seminar devoted to analysis of personnel management activities and their impact on organizational objectives and administration. Cases, incidents, field data from a variety of institutional settings provide framework for examining various roles played by personnel managers. Evolution and formalization of personnel activities within growing

small businesses. Field work and preparation of individual cases for class presentation required.

**666 Administrative Theory and Practice.** General survey of theory and practice of administration. Organizational differentiation and its implication to managerial practices. Taught around cases and field studies. Topics: theories and approaches to administration, organizational diagnosis, managerial practices, organizational dynamics.

**667 Current Issues and Research in Human Resources Development.** Seminar dealing with development of managerial and work-force skills (particular emphasis determined with group). Papers and class discussions. Topics: management development, impact of technological change on training programs, development of scientific and professional personnel, or labor union education.

**668 Manpower Planning, Selection, and Utilization.** Analysis of staffing process as applied to employing organizations. Topics: manpower planning; sources of manpower and methods used to develop these sources; methods and techniques used to assess individual differences in skills, abilities, attitudes; methods used to assess organizational job requirements; problems associated with man-job matching within organizations for maximum utilization of human resources; relationship between staffing process and other organizational processes. Also, current topics in the field, e.g., discrimination in employment and assessment of managerial potential.

**669 Administration of Compensation.** Development and administration of wage and salary programs. Role of compensation in attracting, retaining, motivating employees. Topics: motivation theory; factors influencing compensation levels; job evaluation; forms of compensation, including incentive plans and fringe benefits; special issues of managerial compensation; problems of compensation control.

**760 Manpower and Organization Management.** Basic graduate course. Manpower and organizational management as they relate to human behavior in work organizations. Personnel work: job attitudes, motivation, task design, leadership, manpower planning, recruitment and selection, training, management development, compensation. Application of theory and research to solution of personnel problems.

**761 Occupational Aspects of Manpower Studies.** Job analysis process and its conventional contributions to various personnel activities. Professional and organizational careers, especially their accessibility and adaptability to poor, undereducated, and otherwise disadvantaged people. Individual student projects consist of preparing job descriptions of various career stages of one high-talent occupation, beginning with least demanding and ending with most demanding. These projects examined by outside manpower experts in appropriate specialty.

**762 Design and Administration of Training Programs.** Development of training programs in government, business, labor, voluntary organizations. The role of line and staff and problems and techniques in policy determination, identification of training needs, and design, implementation, evaluation of programs. Case studies focus on philosophy and administration of selected programs.

**763 Alternative Approaches to Manpower Planning.** Seminar. Rationale for manpower planning, relationships between such planning and educational and economic planning. Alternative approaches to manpower planning: (a) manpower requirement approach, (b) rate-of-return approach, (c) programming approach using previous two approaches in combination. Applications to developing and developed countries examined. Individual research paper required. Sound grounding in statistics and mathematics desirable.

**799 Directed Studies.** For individual research under direction of a member of faculty.

## Organizational Behavior

Graduate students majoring or minoring in the area of organizational behavior normally complete the core offering in this area, Organizational Behavior I and II (720,721). Both courses may be taken in same term or in different terms with either course preceding the other. In addition, graduate students majoring in organizational behavior normally take Behavioral Research Theory, Strategy, and Methods I and II (723,724) and an appropriate statistics course. Further details on Ph.D. requirements are included in the Department's annual brochure.

**620 Theories and Methods of Organizational Change.** Works of Perrow, Haig and Aiken, Lawrence and Lorsch, Becker and Gordon, etc., as they relate to organizational change. Problem of maximizing benefit of coordination versus need of organizations to adjust to environmental changes. Attempts made to design optimal organizational forms in terms of environmental imperatives. All concepts scrutinized in terms of empirical validation.

**621 Management of Science.** Management of science on both the micro- and macro-levels. Empirical findings as they bear on national policy and environmental settings. Current problems such as freedom and control of science, scientific secrecy, bureaucracy and creativity, financial and political underpinnings of research, the emerging social system of science.

**622 The Organization and Its Environment.** Survey of literature on organization-environment and interorganizational relationships. Two tasks: developing typologies of interorganizational relations, and exploring methods of measuring or quantifying such relations. Students write research paper applying organization-environment or interorganizational perspective to particular set of organizations.

**624 Individual Differences and Organizational Behavior.** Substantive analysis of accumulated research evidence on relationship of human ability, aptitude, interest patterns to significant criteria of organizational effectiveness. Such variables as intelligence, task expertise, motor skills, clerical skills, cognitive styles, interaction potential, vocational interest profiles. Variety of occupational categories and organizational settings included. Racial and age variables also considered.

**625 Cross-Cultural Studies of Work and Institutional Development.** Research seminar devoted to analysis of survey and anthropological field reports from Peruvian villages, industrial plants, and schools, and from comparable United States organizations. Each student selects a problem area for analysis and writes a research paper.

**627 Leadership In Organizations.** Seminar designed to examine theories and research findings from behavioral sciences relevant to leadership and influence process in groups and organizations. Personality, situational factors, intragroup processes, interpersonal perception, and motivation to lead and to follow. Implications for leadership training, organization development, action research.

**628 Cross-cultural Studies of Organizational Behavior.** Advanced seminar. Cross-cultural studies in values, interpersonal relations, organizational structure. Appropriateness of various organizational strategies to certain cultural and subcultural contexts. Problems relating to authority, decision making, achievement motivation, change. Consequences of these considerations for the transfer of technology and organizational development. Implications for the establishment of new organizational strategies in highly developed and technologically sophisticated organizations and organizations in underdeveloped countries.

**629 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 examined for their utility in understanding of organizational functioning. Relationship of personality to economic development. Participants encouraged to write term paper on interrelationship of technology and values.

**720 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. Relationship between research findings and application to organizational problems. 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.

**721 Organizational Behavior II.** Formal organizations studied from the perspectives of classical organization theory, human relations theory, comparative and cross-cultural analysis. Contemporary theories and quantitative approaches to organizational structure. Preliminary to more intensive work in organizational behavior.

**722 Theories of Organization.** For students interested in more intensive work in theories of organizations and organizational behavior. Works of the intellectual predecessors of the field, Marx, Weber, Durkheim, and contemporary works such as those of Homans, Blau, Caplow, Barnard, March and Simon, Etzioni, Crozier, Dahrendorf.

**723-724 Behavioral Research Theory, Strategy, and Methods I and II.** Units of material include theoretical, conceptual, ethical questions; survey research and attitude scaling procedures; laboratory research methods; participant observation and interview methods; the use of documents and qualitative data analysis. Provides important philosophical background for doing research and exposes student to well-balanced, interdisciplinary set of quantitative and qualitative research tools. Readings supplemented by projects and laboratory exercises. For candidates majoring in organizational behavior, but other graduate students may enroll.

**725 Analysis of Published Research in Organizational Behavior.** Advanced research methods. Critical examination of published research papers in terms of research design and method as well as theory in the field of organizational behavior.

**726 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, others.

**727 Proseminar in Organizational Behavior.** 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, organizational change.

**799 Directed Studies.** For individual research conducted under direction of member of faculty.

**Sociology 403 Sociology of Science and Technology.** Examination of the relationships between the scientist and society, and of the effects of scientist on society and vice versa.

## International Agricultural and Rural Development

**600 Seminar: International Agricultural Development.** Seminar. Primarily for graduate students interested in an integrated view of problems related to international agricultural development. Nature and interrelatedness of agricultural development to the social sciences, plant and animal sciences, foods and nutrition, natural resources.

**601 Philippine Agricultural Development: Policy and Administration.** Major aspects of Philippine agricultural development considered from economic, social, technological points of view.

**602 Special Studies of Problems of Agriculture in the Tropics.** Provides interdisciplinary exchange among students with career interests in tropical agriculture, and opportunity to extend academic studies to a field situation. Field-study trip to Puerto Rico in collaboration with University of Puerto Rico. Topics: problems in soil science, crop science and plant breeding, crop protection, livestock production in context of social and economic conditions. First half of semester is interdisciplinary; in second half individual disciplines meet separately.

**Agricultural Economics 150 Economics of Agricultural Geography.**

**Agricultural Economics 452 Studies in Regional Agricultural Development.**

**Agricultural Economics 464 Economics of Agricultural Development.**

**Agricultural Economics 660 Food, Population, and Employment.**

**Agricultural Economics 665 Seminar on Latin American Agricultural Policy.**

**Agricultural Economics 668 Seminar in the Economics of Agricultural Development.**

**Agricultural Economics 751 Seminar on Agricultural Policy.**

**Agricultural Economics 769 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 Clay Mineralogy.**

**Agronomy 422 Tropical Agriculture.**

**Agronomy 480 Management Systems of Tropical Soils.**

**Agronomy 522 Special Studies in Tropical Agriculture.**

**Agronomy 614 Grasslands and Grassland Research.**

**Animal Science 400 Livestock Production In Warm Climates.**

**Animal Science 403 Forages of the Tropics for Livestock Production.**

**Communication Arts 501 International Communication.**

**Communication Arts 524 Communication In Developing Nations.**

**Education 524 Designing Extension and Continuing Education Programs.**

**Education 525 Educational Communication.**

**Education 532 Advanced Methods and Materials of Teaching Agricultural and Occupational Education.**

**Education 627 Behavioral Change In International Rural Modernization.**

**Food Science 403 International Food Science and Development.**

**Food Science 507 High Protein Food Technology.**

**Natural Resources 511 International Natural Resources.**

**Nutrition 580 International Nutrition Problems, Policy, and Programs.**

**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 Social Systems.**

**Rural Sociology 420 Social Change In Community and Regions.**

**Rural Sociology 516 Macrostructural Research Methods.**

**Rural Sociology 528 Applications of Sociology to Development Programs.**

**Rural Sociology 631 Seminar: Contemporary Social Theory II.**

**Vegetable Crops 429 Special Topics In Plant Science Extension.**

**Vegetable Crops 501 Research Methods In Applied Plant Science.**

## Landscape Architecture

**481 Contemporary Issues In Landscape Architecture.** Current issues in landscape architecture addressed, including role of landscape architect in contemporary society. Recent technological, methodological, legislative developments evaluated in terms of their effects on role of landscape architect.

**581 Landscape Planning and Design Workshop.** Project-oriented. Integrates various disciplinary and

professional skills in designing environmental modifications that optimize relationships with ecological systems. Various elements of land modification process: suitability, impact analysis, planning, design, management. Intended to heighten student awareness of ecological systems factors in planning and design; to develop skills in the practical analysis and synthesis of data and in verbal and visual communication of alternatives to a client group. Orientation to real client group compels awareness of temporal and economic constraints and serves as introduction to project administration.

**582 Landscape Planning and Design Workshop.** Continuation of work undertaken in 581.

**682 Social Factors In Landscape Design.** Introduction to use of social science findings and structured observational techniques in landscape design. User behavior in local open spaces observed, analyzed, evaluated. Assessment of quality of existing local open spaces leads to design of space which emphasizes safety and utility among other user needs.

Additional courses in Landscape Architecture are listed in the Announcement of the *New York State College of Agriculture and Life Sciences: Courses.*

## Latin American Studies

Full descriptions for the following courses will be found under the individual field listings.

**Agricultural Economics 464 Economics of Agricultural Development.**

**Agricultural Economics 650 Food, Population and Employment.**

**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 422 Tropical Agriculture.**

**Agronomy 481 Special Studies In Soils of the Tropics.**

**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.**

**Anthropology 418 Ethnohistory.**

**Anthropology 456 Meso-American Thought and Culture.**

**Anthropology 631 Middle America.**

**Anthropology 632 South America: Lowland Research.**

**Anthropology 633 Andean Research.**

**Anthropology 667 Origins of Meso-American Civilizations.**

**City and Regional Planning 710 Introduction to Urban and Regional Planning.**

**City and Regional Planning 860 Introduction to Regional Development Planning.**

**City and Regional Planning 863 Regional Planning and Development in Developing Countries.**

**Development Sociology 456 Rural Development and Cultural Change.**

**Development Sociology 516 Macrostructural Research Methods.**

**Development Sociology 517 Macrosociological Description of a Whole Country.**

**Development Sociology 528 Applications of Sociology to Development Programs.**

**Economics 525 Economic History of Latin America.**

**Economics 565 Economic Problems of Latin America.**

**Economics 568 Contemporary Brazil.**

**Economics 648 Issues in Latin America (Also Sociology 648 and Government 688).**

**Government 688 United States Presence in Latin America (Also Sociology 648 and Economics 648).**

**Government 650 Government and Politics of Latin America.**

**History 210 The Colonial Experience in Latin America.**

**History 211 Latin American History in the Nineteenth and Twentieth Centuries.**

**History 306 Quantitative Approaches in History.**

**History 703-704 Supervised Reading.**

**History of Art 315 Pre-Columbian Art.**

**History of Art 392 Latin American Art.**

**History of Art 510 Seminar in Latin American Art.**

**Industrial and Labor Relations 625 Cross-Cultural Studies of Work and Institutional Development.**

**Linguistics 405-406 Sociolinguistics.**

**Sociology 434 Sociology of Human Fertility.**

**Sociology 530 Introduction to Social Demography.**

**Sociology 648 Seminar: The U. S. Presence in Latin America. (Also Economics 648 and Government 688).**

**Spanish 329 Spanish-American Literature to "Modernismo".**

**Spanish 330 Spanish-American Literature from "Modernismo" to the Present.**

**Spanish 331 Twentieth-Century Spanish-American Drama.**

**Spanish 333 The Novel and the Mexican Revolution.**

**Spanish 336 The Modern Spanish-American Novel.**

**Spanish 338 Modern Spanish-American Poetry.**

**Spanish 401 History of the Spanish Language.**

**Spanish 403 The Grammatical Structure of Spanish.**

**Spanish 530 Seminar: Latin American Literature: Borges and Mallea.**

**Spanish 601 Hispanic Dialectology.**

**Spanish 602 Linguistic Structures of Ibero-Romance.**

**Spanish 603 Contemporary Theories of Spanish Phonology.**

**Spanish 604 Contemporary Theories of Spanish Grammar.**

**Spanish 700 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

**201-202 Phonetics.** Practical, experimental, theoretical aspects of articulatory and acoustical phonetics.

**203 Multilingual Societies and Cultural Policy.**

**303 Phonology.**

**304 Morphology.**

**306 Syntax.**

**308 Dialectology.** General survey of study of dialectal variations in language and various methodological problems in European and non-European languages.

**311-312 The Structure of English.**

**325 Teaching as a Foreign Language.**

**341 India as a Linguistic Area.**

**400 Analytic Techniques.** Practical training course in techniques of observation and analysis of descriptive linguistics.

**401 Linguistic Structures.**

**402 Contrastive Analysis.**

**403 Applied Linguistics and Second Language Acquisition.**

**404 Comparative Methodology.** Study of the methods and techniques in comparative linguistics; application of these methods in various language families.

**405-406 Sociolinguistics.**

**411-412 Transformational Analysis.** Introduction to the theory, literature, practice.

**413-414 Generative Phonology.**

**440 Dravidian Structures.** Synchronic examination of phonological and grammatical structures of major languages of the family. Typological studies in Dravidian languages.

**442 Indo-Aryan Structures.** Synchronic examination of phonological and grammatical structures of major Indo-Aryan languages. Typological studies in languages of the family.

**600 Field Methods and Linguistic Typology.**

**601 Literature, Language, and Culture.** Survey of relation of literature to its linguistic medium and cultural matrix.

**602 Pidgin and Creole Languages.** Survey of the field of pidginized and creolized languages with discussion of methodological problems, historical relationships, reading of selected texts.

**603 History of Linguistics.**

**605-606 Linguistic Data Processing.** Brief survey of general computer design and techniques and elementary training in SNOBOL stressing character manipulation. Attention given to computability of linguistic problems; student expected to devise solutions to problems from their own data.

**607 Schools of Linguistics.** Comparative survey of principal schools of modern linguistics.

**608 Discourse Analysis.**

**610 Topics in Transformational Grammar.**

**623-624 Old Irish.**

**625-626 Middle Welsh.**

**627 Advanced Old Irish.**

**628 Comparative Celtic Grammar.**

**629 Advanced Middle Welsh.**

**631-632 Comparative Indo-European Linguistics.** Comparative study of phonology and morphology of Indo-European languages and of their interrelationships.

**640 Elementary Pall.**

**641-642 Elementary Sanskrit.**

**644 Comparative Indo-Aryan.** Comparative reconstruction of proto-Indo-Aryan phonology and grammar.

**646 Comparative Dravidian.** Comparative reconstruction or proto-Dravidian phonology and grammar.

**651-652 Old Javanese.**

**653-654 Seminar In Southeast Asian Linguistics.** In alternate terms descriptive and comparative studies of mainland Southeast Asian languages. Topics may be selected in accordance with interests of students.

**655-656 Malayo-Polynesian Linguistics.**

**657 Seminar In Mon-Khmer Linguistics.**

**662 Sino-Tibetan Linguistics.** Descriptive and comparative studies of Chinese dialects and Tibeto-Burman languages.

**671-672 Comparative Slavic Linguistics.**

**700 Seminar.** Subject to needs of students and to limitations of staff time, advanced seminars are set up with 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, semantic theory.

**701-702 Directed Research.**

**751 Thai Dialectology.**

**752 Comparative Thal.**

**753 Tibeto-Burmese Linguistics.**

## Chinese

**401-402 History of the Chinese Language.**

**403 Linguistic Structure of Chinese: Phonology and Morphology.**

**404 Linguistic Structure of Chinese: Syntax.**

**405 Chinese Dialects.**

**607 Chinese Dialect Seminar.**

## French

**401-402 History of the French Language.**

**403 Linguistic Structure of French.**

**600 Semantic: Structure of French.**

**601 Gallo-Romance Dialectology.**

**602 Linguistic Structures of Old and Middle French.**

**700 Seminar In French Linguistics.**

## German

- 402 History of the German Language.
- 408 Linguistic Structure of German.
- 601 Introduction to Germanic Linguistics.
- 602 Gothic.
- 603-604 Old Saxon, Old High German, Old Low Franconian, Old Frisian.
- 710 Seminars in Germanic Linguistics.
- 720 Seminar in Comparative Germanic Linguistics.
- 730 Seminar in German Linguistics.
- 740 Seminar in Dutch Linguistics.

## Hindi

- 401 History of Hindi.
- 700 Seminar in Hindi Linguistics.

## Italian

- 402 History of the Italian Language.
- 403 Structure of Italian.
- 432 Italian Dialectology.
- 700 Seminar in Italian Linguistics.

Indonesian 300 Linguistic Structure of Indonesian.

- Japanese 404 Linguistic Structure of Japanese.
- Quechua 700 Seminar in Quechua Linguistics.

## Romance Linguistics

- 321-322 History of the Romance Languages.
- 323-324 Comparative Romance Linguistics.
- 620 Areal Topics in Romance Linguistics.
- 621 Problems and Methods in Romance Linguistics.
- 622 Romance Dialectology.

## Russian

- 401-402 History of the Russian Language.
- 403 Linguistic Structure of Russian.
- 601 Old Church Slavic.
- 602 Old Russian.
- 700 Seminar in Slavic Linguistics.

## Spanish

- 401 History of the Spanish Language.
- 402 Old Spanish Texts.
- 403 The Grammatical Structure of Spanish.

## 601 Hispanic Dialectology.

## 602 Linguistic Structure of Ibero-Romance.

## 603 Contemporary Theories of Spanish Phonology.

## 604 Contemporary Theories of Spanish Grammar.

## 700 Seminar in Ibero-Romance Linguistics.

## Tagalog 300 Linguistic Structure of Tagalog.

For other relevant courses see also Anthropology, Classics, English Language and Literature, Human Development and Family Studies, Philosophy, Psychology.

# Materials Science and Engineering

## Graduate Core Program

**ITF701 (6601) Topics in Thermodynamics and Kinetics.** Postulates of thermodynamics and statistical mechanics. Ensembles and distribution functions. Applications of Fermi-Dirac, Bose-Einstein, classical distribution functions. Free energy functions and phase equilibria. Statistical thermodynamics of solutions, surfaces and interfaces, point defects. Elements of irreversible thermodynamics. Reaction kinetics and diffusion processes in condensed systems. At the level of *Thermodynamics* by E. A. Guggenheim, *Statistical Thermodynamics* by T. Hill, *Diffusion* by P. G. Shewmon.

**ITF702 (6602) Phase Transformations.** Nucleation theory. Growth theory. Formal theory of nucleation and growth transformations. Spinodal decomposition. Diffusionless transformations. Topics include: crystal growth from the vapor, solidification, eutectic transformations, solid-state precipitation, eutectoid transformations, martensitic transformations with emphasis on heat treatment of steels, transformations in polymers and glasses. At the level of *Phase Transformations*, *American Society of Metals*, 1970.

**ITF703 (6603) Elasticity and Physical Properties of Crystals.** Elastic stress and strain, constitutive relations between stress and strain, elastic wave propagation in crystals, stress fields of dislocations, thermal stresses, stresses at cracks, generalized tensor representation of reversible physical properties of crystals, irreversible thermodynamics, the Onsager relations and transport phenomena in crystals. At the level of *Physical Properties of Crystals* by Nye.

**ITF704 (6604) Plastic Flow and Fracture of Materials.** Introduction to the theory of dislocations. Strain hardening. Dislocation dynamical treatment of yield and flow. Polycrystalline hardening. Interaction of interstitial solute atoms with dislocations. Solution hardening. Two-phase hardening. Time- and temperature-dependent deformation. Dislocation models for cleavage of crystals. Viscosity and visco-elastic behavior. Theories of rubber elasticity. Newtonian and nonlinear viscous flow. Creep and creep rupture. Ductile fracture and the fracture of

rubber. Fatigue. At the level of *Elementary Dislocation Theory* by Weertman and Weertman, review articles in *Progress in Materials Science*, and various conference reports.

**ITF705 (6605) Materials Processing.** Topics in materials processing selected from: solidification processes such as casting, welding, directional solidification; mechanical processing such as rolling, swaging and drawing; thin film technology; ion implantation; electrochemical processing; diffusional processing; solid-state processing including heat treatment of steels, alloys, precipitation strengthening, recrystallization. At the level of articles in *Metallurgical Reviews*.

**ITF706 (6606) Principles of Diffraction (Applied Physics IPB711 [8211]).** Broad introduction to diffraction phenomena as applied to solid-state problems. Production of neutrons and X-rays, scattering and adsorption of neutrons, electrons, 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 and Bragg reflections. Standard crystallographic techniques for single crystals and powders. Diffraction from almost periodic structures, surface layers, gases, and amorphous materials. Survey of dynamical diffraction from perfect and imperfect lattices. Techniques for imaging structural defects. At the level of *Optical Principles of the Diffraction of X-Rays* by R. W. James, *X-Ray Diffraction* by B. E. Warren, *Electron Diffraction* by Vainshtein, and *Electron Microscopy of Thin Crystals* by Hirsch, et al. Lectures and experiments on fluorescence and polarization of X-rays, diffractometer measurements of vibrational amplitudes in crystals, natural widths of emission lines, identification of crystal structures, crystal orientation by back reflection techniques.

**ITF707 (6607) Introductory Solid State Physics.** Semiquantitative introduction to modern solid state physics, including lattice structure, lattice vibrations, thermal properties, electron theory of metals and semiconductors, magnetic properties, superconductivity. At the level of *Introduction to Solid State Physics*, 3rd edition by Kittel.

## Other Graduate Courses

**ITE553-ITE554 (6553-6554) Project.** Research on a specific problem in materials or metallurgical engineering.

**ITF712 (6612) Selected Topics in Diffraction (Applied Physics IPB712 [8212]).** 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, vibrational amplitudes. Diffuse scattering, short- and long-range order, precipitation in solids, point defects.

**ITF714 (6614) Electron Microscopy.** Electron optics. Kinematical theory of diffraction with

applications to the imaging of stacking faults, dislocations, inclusions, etc. Dynamical theory of diffraction as applied to calculation of images of various defects. Interpretation and analysis of electron diffraction problems. Application of stereographic projection to problems in microscopy (e.g., indexing of diffraction patterns from single crystals containing oriented second phases). Applications of dark field microscopy. Instruction in use of the microscope. Series of experiments.

**ITF725 (6625) Composite Materials (Theoretical and Applied Mechanics IAB680 [1280]).** Physical basis of strength, elastic modulus, fracture resistance of composite materials; the micro- and macromechanics 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.

**ITG762 (6762) Physics of Solid Surfaces (Applied Physics IPB762 [8262]).** Equilibrium thermodynamics and statistical mechanics of interfaces. 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. Condensation and evaporation processes. Experimental techniques: discussion of low energy electron diffraction, field ion microscopy, field emission microscopy, etc. Materials drawn from research papers and various review articles in journals such as *Progress in Materials Science*, *Advances in Chemistry*, *Solid State Physics*.

**ITG763 (6763) Environmental Degradation of Materials.** Corrosion of industrial alloys in natural environments. Electrochemistry of corrosion in stagnant and convective situations; kinetic models for rate of attack. Passivation and pitting. Stress corrosion and hydrogen brittleness. Environmental attack on glasses and polymers, static fatigue and crazing. Interactions between nonmetallic surfaces and environmental constituents.

**ITG765 (6765) Amorphous and Semicrystalline Materials.** Topics related to science of amorphous state selected from within the following: structure of liquids and polymers; rheology of elastomers and glasses; electrical, thermal, and optical properties of amorphous materials. Presented at the level of *Modern Aspects of the Vitreous State* by Mackenzie, *Glass Transitions* by Shen and Eisenberg in *Progress in Solid State Chemistry*, and *The Physics of Rubberlike Elasticity* by Treloar.

**ITG767 (6767) Electrical and Magnetic Properties of Materials.** Electronic transport properties of metals and semiconductors, semiconductor devices, optical and dielectric properties of insulators and semiconductors, laser materials, dielectric

breakdown, structural aspects of superconducting materials, ferromagnetism and magnetic materials. At the level of *Physics of Semiconductor Devices* by Sze, *Ferromagnetism* by Bozworth, and current review articles.

**ITG768 (6768) Theory of Crystal Defects.**

Structure and properties of point, line, planar crystal defects treated from a fundamental point of view. Thermodynamics and kinetics of point defects. Atomistic and continuum theories of dislocations. Thermodynamic treatment of grain boundaries. Structure of grain boundaries. Emphasis throughout to interactions between various types of defects and to their roles in important phenomena such as diffusion, precipitation, plasticity, radiation damage. At the level of *Point Defects and Diffusion* by Flynn, *Theory of Dislocations* by Hirth and Lothe, and *High Angle Grain Boundaries* by Gleiter and Chalmers.

**ITG769 (6769) Ceramic Materials.** Crystal structure and bonding of typical ceramic materials; structure of silicate and nonsilicate glasses, imperfections in oxides; point defects and point defect chemistry, line defects, extended defects; diffusion to stoichiometric and nonstoichiometric ceramics; phase transformations; equilibrium and non-equilibrium phases; grain growth and sintering; plastic deformation and creep; topics from research papers. At the level of *Introduction to Ceramics* by Kingery, *Ionic Crystals, Lattice Defects and Nonstoichiometry* by N. N. Greenwood, and selected research papers.

## Mathematics

### Applied Mathematics and Differential Equations

**315 Higher Calculus.** Vector analysis. Ordinary and partial differential equations. Fourier series. Special functions. Laplace transforms. Emphasis on a wide range of formal applications of calculus rather than on logical development.

**415-416 Mathematical Methods in Physics.**

Lectures and problems designed to give a working knowledge of principal mathematical methods used in advanced physics. Topics: metric spaces, vector spaces, linearity, continuity, integration. Generalized functions (Schwartz distributions). Fourier series and Fourier integrals. Elementary complex variables. Saddle point method. Linear transformations in finite- and infinite-dimensional spaces. Matrices. Differential operators and integral operators, equations and eigenvalue problems connected with them, and special functions arising from them. Elements of groups theory. Rotation groups and their 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 viewpoint of equations in complex domain and 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. Equations of Laplace and Poisson, principles of maximum and mean; wave equation, heat equation.

**521 Elementary Functional Analysis.** Elementary set theory and topology, Banach and Hilbert spaces, measure and integration. Graduate students in mathematics should take 613 for functional analysis.

**522 Applied Functional Analysis.** Spectral theorem for bounded operators, spectral theory for unbounded operators in Hilbert space, compact operators, distributions. Applications.

**619-620 Advanced Partial Differential Equations.**

**627-628 Seminar in Partial Differential Equations.**

### Analysis

**411-412 Introduction to Analysis.** Introduction to theory of functions of real variables, stressing rigorous logical development of subject rather than technique of applications. Topics: elementary topology, the real number system, continuous and differentiable functions, integration, convergence and approximation theorems. Fourier series, calculus in several variables and differential forms.

**418 Introduction to the Theory of Functions of One Complex Variable.** 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.** 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 on the  $L^2$  theory, and distributions.

#### 617 Analytic Number Theory.

#### 621 Meromorphic Functions.

#### 622 Riemann Surfaces.

**623 Several Complex Variables.** Introduction to theory of functions of several complex variables. Domains of holomorphy, removable singularities, analytic varieties. Stein manifolds.

## Algebra

**431-432 Introduction to Algebra.** Rigorous introduction to modern algebra. First term: linear algebra. Second term: introduction to algebraic systems such as groups, rings, modules, 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. 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.** Summary of 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.** 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 geometric properties of manifolds.

**651-652 Seminar in Topology.** Students report on important classical and current papers. Topics vary from year to year.

**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.** 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.** Theory of algebraic curves. The Riemann-Roch theorem. Projective embeddings. Singularities.

## Probability and Statistics

**472 Statistics.** Classical and recently developed statistical procedures discussed in framework which emphasizes basic principles of statistical inference and rationale underlying choice of these procedures in various settings. These settings include problems of estimation, hypothesis testing, large sample theory.

**473 or 475 Statistics.** Continuation of 472 in which emphasis is placed on experimental designs, nonparametric statistics, multivariate analysis, sequential analysis, 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. Law 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.

**573 Experimental Design, Multivariate Analysis.** Rationale for selection of experimental designs, and algorithms for constructing optimum designs. Optimum properties and distribution theory for classical analysis of variance procedures and their simplest multivariate analogues.

**575 Sequential Analysis, Multiple Decision Problems.** Properties of sequential statistical procedures as obtained from random walk considerations. The sequential probability ratio test and its optimum properties. Sequential estimation. Two-stage procedures. Multiple decision problems and their treatment by one-, two-, and many-stage procedures.

**577 Nonparametric Inference, Asymptotic Theory.** Tests based on ranks, estimators based on linear combinations of order statistics. Distribution free confidence and tolerance sets. Robustness. Asymptotic distribution theory, efficiency, sufficiency, in parametric and nonparametric settings.

**579 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.**

**674 Experimental Design, Multivariate Analysis.** Selected techniques of combinatorial design construction. Multivariate distribution and optimality theory for more complex settings.

**675-676 Statistical Decision Theory.** General development of statistical decision theory, with application to classical estimation and hypothesis testing as well as to multiple decision problems. Admissibility, complete classes, characterization of Bayes procedures. Invariance. Polya families and other special settings.

**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

**MA671 (3671) Aerospace Propulsion Systems.** Application of thermodynamics and fluid mechanics to design and performance of thermal-jet and rocket engines in atmosphere and space. Mission analysis in space as it affects propulsion system. Consideration of auxiliary power supply; study of advanced methods of space propulsion.

**MB562 (3362) [Vet. Med. RLA678] Mechanics of Biological Materials and Systems.** Basic concepts in engineering mechanics (statics, dynamics, strength of materials). Mechanical properties of biological tissues (bone, soft tissue, muscle). Applications of engineering mechanics to specific biomechanical problems such as fractures, fixation of fractures, strength of suture closure of wounds, analysis of animal motion, mechanical aspects of lameness in horses, total joint replacement (internal prostheses). Intended for students in veterinary medicine and line sciences. Not open to engineering students.

**MB665 (3355) Biomechanical Systems—Analysis and Design.** Selected topics from the study of the human body as a mechanical system. Emphasis on modeling, analysis, design of biomechanical 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. Analysis and design of man-machine systems used in orthopedic surgery and physical rehabilitation.

**MB690 Special Investigations in Biomechanical Systems.** Independent study of current problems involving the analysis and design of biomechanical systems. In most cases investigations involves collaboration with personnel from medical facilities. Work carried out individually or, for relatively large-scale projects, in small groups.

**MD464 (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, shaft mountings and connections. Specifications for manufacturing 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.

**MD663 (3363) Mechanical Components.** Advanced analysis of machine components and structures. Application to design of new configurations and devices. Selected topics from: lubrication theory and bearing design, fluid couplings, torque converters, speed-control devices, shells, thick-cylinders, elastic foundation theory, design of pressure vessels, rotating disks, fits, elastic-plastic design, thermal stresses, creep and relaxation, impact, indeterminate and curved beams, plates, contact stresses, gears, rolling bearings.

**MD672 (3372) Experimental Methods in Machine Design.** Investigation and evaluation of methods used to obtain design and performance data. Techniques of photoelasticity, strain measurement, photography, vibration and sound measurements, development techniques as applied to machine design problems.

**MD674 (3374) Conceptual Design.** Treatment of processes of advanced system or new product evolution as practiced by industry, including product planning, creation of ideas, synthesis into working concepts and evaluation. A working exposure to engineering components. Numerous projects, much discussion, some lectures.

**MD680 (3380) Design of Complex Systems.** Seminar relying heavily on student participation in discussing frontier problems such as systems for space and underwater exploitation, salt water conversion, 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 which set forth recommendations and the reasoning leading to them required.

**MD690 (3390) Special Investigations in Mechanical Design.** Individual work or work in small groups under guidance in the design and development of a machine, in analysis of

experimental investigation of a machine or component.

**MD692 (3392) Special Topics In Engineering Design.** Series of lectures by staff members or visiting staff on subjects of current interest. Topics announced prior to beginning of term. More than one topic may be taken if offered.

**MF632-633 (3632-3633) Fluid Mechanics I and II.** Stress, deformation, mass, momentum, energy and constitutive equations. Incompressible potential flow. Viscous flow, boundary layers, convection heat transfer and separation. Instability and transition. Turbulence and turbulent flows. Body force flows. One dimensional steady and unsteady flows including heat addition and friction. External compressible flow. Reacting flows.

**MF636 (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 high-performance compressor-turbine unit.

**MF734 (7308) Turbulence and Turbulent Flow.** Structure of turbulence and methods of calculating turbulent flows. Topic: mathematical descriptions of turbulence and experimental measurement techniques; Reynolds stress, eddy viscosity and mixing length; structure of turbulence including homogeneous isotropic turbulence, correlations and spectra, inertial and dissipation ranges, effects of shear and buoyancy, energy budget; recent developments in turbulent flow calculation methods.

**MF735 (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 and nonlinear waves in rotating fluids. "Vortex breakdown" in tornadoes and other swirling flows. Theories of vortex breakdown. Boundary layer interactions. Spin-up of fluids in rotating containers. Theoretical course designed 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 included.

**MF737 (3677) Numerical Methods in Fluid Flow and Heat Transfer.** Finite-difference and finite-element methods developed for solving multidimensional fluid flow and heat transfer problems. Basic principles stressed throughout, enabling methods to be extended to wide range of physical problems involving convective and diffusive transport. Physical and numerical restraints imposed on transient and steady-state numerical solutions determined. Recent methods surveyed and compared. Selected examples illustrate applications

involving natural convection, flow over objects and within channels, planetary atmospheres and interiors, flame spread. Assigned problems and final examination require solution of fluid flow problems on a digital computer.

**MF738 (3585) Nonlinear Wave Propagation.**

Emphasis on mathematical treatment of nonlinear effects associated with waves in continua. Some particular examples taken from water waves, gasdynamics, elasticity, plasma physics, electromagnetic theory. Topics: 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, the Burger's equation and its solution. Conservative dispersive systems. Korteweg-deVries equation and 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.

**MG790 (3090) Mechanical Engineering Design**

**Project.** Design of an engineering system or a device of advanced nature. Projects to be carried out by individual students or by small groups with individual assignments culminating in an engineering report by each student. In some cases project carried out in collaboration with external organization, such as an industrial company, research laboratory, or public agency, whose representatives suggest current problems and review final designs.

**MG791 Mechanical and Aerospace Engineering**

**Research Conference.** Short presentations on research in progress by students and staff.

**MG799 (7901) Mechanical and Aerospace Engineering Colloquium.**

Lectures by Cornell staff members, graduate students, and visiting scientists on topics of interest in mechanical engineering and aerospace sciences.

**MG890 Research in Mechanical and Aerospace**

**Engineering.** Independent research for master's candidates in an area of mechanical and aerospace engineering under guidance of a member of staff.

**MG990 Research in Mechanical and Aerospace**

**Engineering.** Independent research for Ph.D. candidates in an area of mechanical and aerospace engineering under guidance of a member of staff.

**MG654 (3654) Environmental Control.**

Environmental living systems; heating, cooling, air conditioning. Refrigeration and cryogenic systems and applications. Artificial environments and life-support systems for space and under water. Production of high vacuum, pressure, temperature and velocity for simulation of special environments; problems of zero gravity.

**MG656 (3656) Advanced Energy and Fluid Systems Laboratory.**

Individually offered experimental studies. Time allotted, and number of

students accepted for each experiment specified by instructor in each case. Available experiments range from performance testing of engine components to studies of laser interferometry.

**MH650 (3665) Transport Processes.**

Description of modes of thermal and mass diffusion and transport. Formulation of 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 buoyance-induced flows emphasized in relation to applications.

**MH651 (3680) Convection Heat Transfer.**

Diffusion of thermal energy, mass, momentum considered. Basic equations reasoned in detail and applied to problems of current importance in technology and in environmental and ecological studies. Natural convection (buoyance-induced) flows adjacent to surfaces and in freely rising plumes, buoyant jets, thermals in extensive media (including stratified) treated for laminar and for turbulent processes. Transient flows and conversion of laminar motion to turbulent motion. Thermal instability and the diffusion characteristics in naturally occurring bodies of fluid. Forced flows and resulting convection; included are effects of property variation and viscous dissipation. Convective 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 given.

**MH652 (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.

**NN612 (3451) Analysis of Manufacturing**

**Processes.** Analytical treatment of processes of material removal and plastic deformation, from interdisciplinary viewpoints of mechanics, thermodynamics, metallurgy. Emphasis placed equally on conventional and unconventional processes involving ultrasonic, high-energy beam, electric-discharge, electrochemical energy sources. Also, economic analysis of production-system and machine-tool dynamics.

**MM614 (3475) Introduction to Numerical Control.**

Broad introduction to numerical control technology, covering both hardware and software aspects. Principles of conventional numerical control systems, adaptive control, direct computer control of machine tools. Manual and computer-aided part programming methods. Extensive exercises in APT programming. Methodology for economic justification.

**MM690 (3490) Special Investigations in Materials Processing.**

Independent study of selected topics concerned with analytical or experimental

investigation of manufacturing processes. Design, manufacture, test of a machine or a component to be used for materials processing. Topics: production systems, quality assurance, metrology, or machine tools, in accordance with individual interests. Work carried out individually or, for relatively large-scale projects, in small groups.

**MP304 (3659) The Nature of Thermodynamics.**

Study of history, philosophy, mathematics of thermodynamics with emphasis on its scope and limitations. Study of methods of exposition of concepts and laws of thermodynamics; comparison of intuitive, axiomatic, statistical approaches. Principle rather than problem oriented, and each student is expected to develop a special topic in thermodynamics, present it orally, and write term paper in place of final examination.

**MP441 (3641) Power Systems.** Broad survey of methods of large-scale power generation, emphasizing energy sources, thermodynamic and fluid mechanical cycle considerations, component description. Power industry, economic, environmental factors. Long-range trends and projections. Fossil-fueled steam-turbine systems. Exhaust emissions, cooling problems and methods. Peak load problems; gas turbine, energy storage schemes. Topping units, binary cycles, MHD.

**MP643 (3652) Combustion Processes.**

Introduction to combustion and flame processes with emphasis on rate-controlling effects of fluid dynamics, heat and mass transfer, reaction kinetics. Topics: classification of fuels; heat of combustion and flame temperature; mixture equilibrium; combustion in homogeneous mixtures; deflagrations, detonations, and explosions; ignition, quenching, and burning limits; flame stabilization; turbulent burning; diffusion flames; burning of droplets and particles.

**MP644 (3691) Processes of Large Scale Heat Rejection.**

Application of fluid mechanics and heat transfer to the analysis of problems of large scale heat rejection. Development of plumes and effects of heat rejection on temperature cycles of water bodies. Performance and size estimation of cooling towers of evaporative and dry types, including role of heat exchanger design in such cooling systems for large power plants. Effects of large scale heat rejection on planetary boundary layer. Dispersion of thermal effluents in the atmosphere. Urban heat islands and regional warming. Discussion of present and future trends in development of heat dispersal methods.

**MP648 (3668) Seminar on Combustion.**

Discussion of contemporary problems in combustion such as combustion generated air pollution, destructive fires, fuels for future combustion systems. Emphasis on the experimental and analytical tools required for current combustion research. Topics: numerical techniques, turbulence modeling, temperature and composition measurements, laser applications.

**MP655 (3672) Energy Conversion.** Primarily an analysis of energy conversion devices as classified into heat engines, chemical engines, expansion

engines. An analysis of each class from the point of view of efficiency and other criteria of performance. More detailed study of some conventional and direct energy conversion devices including thermoelectric, thermionic, and photovoltaic converters and fuel cells. Energy sources and energy storage, application to terrestrial and space power systems.

**MP690 (3690) Special Investigations in Power, Thermodynamics, or Combustion.** Intended either for informal instruction of a small number of students interested in work to supplement that given in regular courses or for a student wishing to pursue a particular investigation outside of regular courses. Permission of director required for registration.

**MS668 (3368) Mechanical Vibrations.** Further development of vibration phenomena in single degree and multidegree 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, noise and its reduction, impedance, matrix, numerical methods. Analog- and digital-computer solutions and laboratory studies.

**MS678 (3378) Automatic Control Systems.** Further development of theory and implementation of feedback control systems with particular emphasis on application of pseudoderivative-feedback (PDF) control concepts to linear and nonlinear systems. Analog-computer simulation and laboratory studies of electromechanical, pneumatic and hydraulic components and systems.

**MS682 (3382) Hydrodynamic Lubrication.**

Designed to acquaint those having a general knowledge of solid and fluid mechanics with special problems and literature currently of interest in various fields of hydrodynamic lubrication. General topics: 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.

**MS685 (3385) Optimum Design of Mechanical Systems.** Formulation, as optimization problems, of design problems frequently encountered in mechanical systems. Emphasis on choice of design objective function and constraints. Finite and infinite dimensional design problems. Theory and application of methods of mathematical programming to solution of optimum design problems. Examples drawn from structures and machine components frequently encountered in mechanical systems.

**MS688 (3388) Computer Simulation and Analysis of Dynamic Systems.**

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.

**MS690 (3390) Special Investigations In Mechanical Systems.** Individual work or work in small groups under guidance in studies in a special field of mechanical systems.

**MS761 (3361) Advanced Mechanical Analysis.** Advanced topics in mechanical design. Selected topics from design optimization, finite-element methods, design reliability, advanced kinematics, systems analysis, computer-aided design, advanced strength of materials.

**MS771 (3371) Computational Methods of Mechanical Analysis.** Modern computer-based methods for mechanical design analysis as applied to motion analysis of linkages, stress-strain and load-deflection analysis of mechanical structures, pressure-flow analysis of bearing lubricant film systems. Methods include finite element-transfer matrices, etc.

**MT305 (7001) Introduction to Aeronautics.** Introduction to atmospheric flight vehicles. Principles of incompressible and compressible aerodynamics, boundary layers, wing theory. Propulsion systems, including analysis of engine types, propellers, fans, rotors. Aircraft performance; maximum speed, rate of climb, range and endurance, takeoff and landing; turning performance; maneuver and gust loads; elements of stability and control.

**MT306 (7002) Introduction to Astronautics.** Topics from the following: mechanics of trajectories and orbits; propulsion systems, including chemical, nuclear, and advanced; guidance, tracking, and communication systems; the problem of reentry; life support. Applications discussed include missiles, communication and navigation satellites, geology, cislunar probes, lunar and planetary exploration, deep space probes.

**MT486 (3377) Automotive Engineering.** Selected topics in analysis and design of vehicle components and vehicle systems. Emphasis on automobile, particularly with regard to powerplant, driveline, brakes, suspension, structure. Other vehicle types considered, including rapid transit and recreational vehicles. Some digital programming experience assumed. Project required.

**MT687 (3387) Dynamics of Vehicles.** Intended as introduction to dynamics of automobiles and trucks. Emphasis on the handling behavior of the automobile. Tire theory, and suspension analysis. Also, articulated vehicle handling, motorcycle dynamics, vehicle safety.

See also the listings under Aerospace Engineering and under Theoretical and Applied Mechanics for many courses of interest.

## Medieval Studies

For further information about courses consult the fields of The Classics, Comparative Literature, English Language and Literature, Germanic Studies, History, History of Art and Archaeology, Music,

Philosophy, Romance Studies, Semitic Studies, and Slavic Studies.

## Classics

367-368 Medieval Latin Literature.

## Comparative Literature

332 Latin Foundations of Western Literature.

343-344 Medieval Literature.

446 Allegory and Symbolism.

639-640 Special Topics in Medieval Studies.

## English

601 Readings in Old English.

602 Beowulf.

603 Middle English.

609 Chaucer.

675 Studies in the English Language.

710 Studies in Medieval Literature.

## French

401-402 History of the French Language.

447 Medieval Literature.

602 Linguistic Structures of Old and Middle French.

## Germanic Studies

402 History of the German Language.

405-406 Introduction to Medieval Literature.

602 Gothic.

603-604 Old Saxon, Old High German, Old Low Franconian, Old Frisian.

609-610 Old Norse.

611 Heroic Poetry and Heroic Legend in Icelandic.

612 Icelandic Family Sagas.

623 Middle High German Literature I.

624 Middle High German Literature II.

730 Seminar in Germanic Linguistics.

## History

263-264 Medieval History.

357 English Constitutional History I: To 1485.

365 Medieval Culture, 400-1150.

366 Medieval Culture, 1150-1300.

367 Church and State During the Middle Ages.

663 Seminar in Medieval History.

664-665 Seminar in Latin Paleography.

666-667 Seminar in Medieval History.

## History of Art

332 Architecture of the Middle Ages.

333 Early Medieval Art and Architecture.

334 Romanesque Art and Architecture.

335 Gothic Art and Architecture.

336 Medieval Italian Art.

341 Flemish Art.

342 Medieval and Renaissance German Art.

531 Problems in Medieval Art and Architecture.

## Italian

327-328 Dante.

402 History of the Italian Language.

435 Boccaccio.

438 Petrarch.

## Jewish and Islamic Philosophy

242 Jewish Philosophy in the Post-Maimonidean Period.

243 Seminar in Jewish and Islamic Philosophy.

## Linguistics

449 Areal Topics in Romance Linguistics.

623-624 Old Irish.

625-626 Middle Welsh.

671-672 Comparative Slavic Linguistics.

## Music

616 Music and Poetry in France: Late Middle Ages and Renaissance.

783-784 Seminar in Medieval Music.

## Philosophy

313 Medieval Philosophy.

612 Medieval Philosophy.

## Romance Linguistics

321-322 History of the Romance Languages.

## Russian

401-402 History of the Russian Language.

601 Old Church Slavc.

602 Old Russian.

621 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.

## Microbiology

### 390 Advanced General Microbiology.

Consideration of the morphological, taxonomic, cultural, physiological characteristics of important groups of heterotrophic microorganisms.

### 391 Advanced General Microbiology Laboratory.

Intended as laboratory component of 390 A. Isolation, characterization, study of cultures of microorganisms representative of important groups of heterotrophs.

**394 Food Microbiology.** Major families of microorganisms of importance in foods studied systematically with emphasis on role played by these organisms in food preservation, food fermentations, public health.

**395 Food Microbiology Laboratory.** Laboratory component of 394 A. Practice in use of general and special methods for microbiological testing and control of food products and practice in isolation and characterization of organisms found in food.

**412 Aquatic Microbiology.** Consideration of relation of microorganisms, especially bacteria, to aquatic environments, both natural and artificial. Microbiology of waste waters included. Fundamental biological concepts and applied aspects of occurrence and activities of microorganisms in water.

**485 Microbial Genetics Lecture.** Genetics of bacteria and their viruses, with emphasis on mechanisms of genetic phenomena.

**486 Microbial Genetics Laboratory.** Laboratory methods in the genetics of bacteria and their viruses.

**490 A Microbial Physiology.** Physiological functions of microorganisms. Particular consideration to dynamics of growth, nutrition, energy metabolism of developing cultures, and effects of physical and chemical environments on growth process.

**491 Microbial Physiology Laboratory.** Laboratory component of 490 A. Selected exercises to illustrate fundamental points discussed in lecture.

**492 Microbial Ecology.** Introduction to the basic principles of microbial ecology. Behavior, activity, interrelationships of bacteria, fungi, algae, protozoa in natural ecosystems.

**496 Selected Topics In Microbial Metabolism.** Selected topics pertaining to the energy metabolism, oxidative and fermentative abilities, biosynthetic capacities of microorganisms. Where possible and appropriate, various microbial forms compared.

**590 Methods In Advanced Bacteriology.**

**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.

See also Agronomy 506; and Veterinary Medicine 705, 706, 707, 708, 709.

## Music

**616 Music and Poetry In France: Late Middle Ages and Renaissance.** Changing interrelations between vernacular poetry and secular music from late fourteenth century to time of Ronsard.

**651 Introduction to Twentieth-Century Music.** Analysis of representative works by important composers in first half of twentieth century, including Bartok, Hindemith, Schoenberg, Stravinsky, Webern, some American composers.

**653 Analysis of Structure and Function in Tonal Music.** Introduction to systematic analysis of thematic and formal structure from phrase, subphrase, and motive to movement as a whole. Concept of harmonic function expanded to include key function, and the two levels interrelated through graphic representation of their profiles. Emphasis on Viennese classics, and attention to process of tonal expansion in the nineteenth century.

**657-658 Composition.** Intended to acquaint student with compositional practices in contemporary styles and to develop creative abilities.

**681-682 Introduction to Bibliography and Research.** Basic materials and techniques of musicological research.

**683 Early Theories of Tonality.** Formulations of representative theorists of modality, figured bass and root progression examined for light they shed on emergence of tonality. Validity of theoretical statements tested through analysis of contemporaneous music.

**684 Seminar In Renaissance Music.** Important musical manuscript transcribed and its musical, literary, social background investigated.

**685 Schoenberg, Bartók, and Stravinsky.** Comparative stylistic study, through performance and analysis, of representative works of the three composers.

**686 Beethoven.** Representative works from various periods and genres analyzed with emphasis on development of style, both within Beethoven's *oeuvre* and in somewhat larger historical context.

**687 Mozart.** Research in music of Mozart and his contemporaries.

**689 Haydn.** Research into philological, historical, analytical problems arising out of Haydn's music.

**754 Seminar In Analytic Techniques for Twentieth-Century Music.** Detailed analysis of limited number of larger works representative of main trends in twentieth-century music. Different works chosen each year.

**756 Problems In Music Theory.** Preparation of twentieth-century music research projects for M.F.A. and D.M.A. degrees.

**783-784 Seminar In Medieval Music.** Selected topics from Middle Ages with special attention to development of measured notation and to problems of preparing scholarly editions of early music.

**787-788 Debussy to Boulez.** Historical studies in twentieth-century music. Each student studies many works of a single composer, in relation to that composer's life and thought and especially his knowledge of other music. Composers chosen in accordance with student's abilities and interests.

**788-790 Liturgical Chant in the West.** Study of selected aspects of the liturgical chant of Western Christian rites during Middle Ages.

## Natural Resources

**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 Natural Resources are expected to participate.

## Aquatic Science

**443 Ecological Aspects of Water Resources Management.** Basic structural and dynamic aspects of freshwater and estuarine ecosystems reviewed. Nature and modes of action of stresses imposed by man on these systems and their significance to management decisions. Students become acquainted with some 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, relationships of fishes to other organisms. Adaptations, diversity of life history and behavior patterns, usual inhabitants of major habitat types considered. Ecology of young fishes stressed, and student introduced to 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, investigational aspects of fishery biology included. Laboratory consists of field experience in obtaining and analyzing information necessary for estimating vital statistics of fish populations.

**441 Fishery Resource Management.** Principles and problems in 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, economic, legal, 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, regulation of fishing.

#### **494 Research In Fishery Biology.**

**600 Seminar: Major Fishery Investigations.** Comparative review of major fishery investigations of world constitutes primary content of seminar. Study of pertinent literature and special topics 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 natural resource management professions through use of effective communications, media, biopolitics, understanding public involved.

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

**420A Field Studies In Outdoor Recreation.** Laboratory 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 described and their sensor capability identified. Current and potential applications for sensing natural resources considered and simulated, actual problems of benefit analysis undertaken.

**430 Population Dynamics of Fish and Wildlife.** Characteristics of fish and game populations and analysis of data for purposes of projection. Examination of processes that control abundance of organisms. Course includes consideration of mortality, reproductive potential, density-dependent and density-independent regulation, predator-prey and parasite-host relationships. Examples taken mainly from areas of fishery and wildlife science. Emphasis on 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.** Seminar based on extensive readings of articles highlighting varying philosophical approaches to conservation of natural resources. Views espoused by developmentalists, preservationists, naturalists, economists, welfare economists, urban planners.

**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; relevance of U.S. experience; role of nature conservancy in resource development of emerging nations. Foreign students especially invited.

**602 Seminar in Natural Resources Analysis for Ecologically Based Planning.** Multidisciplinary graduate student-faculty-invited specialists seminar. Theme varies from year to year but usually involves case study of specific area of land and water. Ecological basis for planning land and water use. Engineers, economists, sociologists, soil scientists, fish or wildlife biologists, foresters, ecologists, 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 basic physical, physiological, interspecific, intraspecific relationships of organism and its environment.

**410 Principles of Wildlife Management.** Fundamental characteristics and mechanisms of wildlife population and habitats. Includes ecological, social, 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, 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, behavioral relationships between free-ranging animals and their environment. Domestic and wild animals; emphasis on wild and domestic ruminants and upland game birds.

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

## Neurobiology and Behavior

**321 Neurobiology and Behavior.** Evolution of behavior, cueing of behavior, social and nonsocial behavior, neuroanatomy, neurophysiology, neurochemistry, neural networks, memory.

**322 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 planned and carried out.

**323 Physiological Psychology (Psychology 323).** Selective examination of neural, endocrine, and biochemical functions related to emotion, memory, learning, sleep.

**325 Cellular Organization of the Nervous System.** Cellular organization of nervous system; development, functional relationships, ultrastructure.

**326 Elementary Neurophysiology.** Lectures on biophysical and biochemical properties of excitable membranes of nerve cells and muscle; quantitative analysis and possible molecular mechanisms underlying these properties. Topics: origin of bioelectric potentials, excitability, synaptic transmission, neural circuits, specificity of neural membranes, possible mechanisms for plasticity.

**420 Principles of Neurobiology (Laboratory).** Laboratory practice with neurobiological preparations and experiments. Techniques, experimental designs, and research strategies used to study biophysical and biochemical properties of excitable membranes, sensory receptors and central nervous system transformation of afferent activity, characteristic composition and metabolism of neural tissue. Part I (approx. 8 weeks): fundamental techniques learned and used in experiments by all students; Part II (approx. 8 weeks): students learn and use more specialized techniques for experiments in either neurophysiology of excitable membranes, or sensory function, or neurochemistry.

**421 Comparative Vertebrate Ethology.** Survey of 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. Causation, function, biological significance, evolution of species-typical behavior. Laboratories give firsthand knowledge of material covered in lectures.

**423 Animal Communication.** Functional aspects of biological signals, their physical properties, physiological mechanisms underlying their generation and reception. Lectures: selected biological communication problems from each known sensory modalities. Discussion: signal analysis, transmission properties, limitation of each type of communication.

Laboratories: behavioral observations under both field and captive conditions and individual experience with signal recording and analysis.

**426 Neuropharmacology.** Drugs that affect nervous system, both central and peripheral. Mechanisms of drug action whereby basic biochemical processes and neurophysiological and behavioral phenomena are bridged. Drugs range from cholinergic ones to depressants, stimulants, local anesthetics, hallucinogens. Topics: also include drug addition, use of drugs to uncover physiological mechanisms and biochemical basis of therapeutic uses of drugs in diseases of nervous system.

**427 Sensory Function (Psychology 427).** Sensory receptors and central nervous system transformation of afferent activity in relation to human and nonhuman behavior, and to adaptive significance of behavior. Receptor examined in terms of anatomy, biochemistry, biophysics of transduction, central nervous system control of peripheral input.

**428 Neurochemistry.** Special features of composition and metabolism of neural tissue. Identification of synaptic transmitters in nervous system, including their specific localization, biosynthesis and metabolism, axonal transport, release, inactivation, action on postsynaptic receptors. Chemical aspects of neurosecretion, nerve growth factor activity, pineal function.

**429 Research in Neurobiology and Behavior.** Practice in planning, conducting, reporting independent laboratory and/or library research programs.

**523 The Evolution of Social Systems.** Combined lecture-seminar on interrelationships of animal behavior and ecology, emphasizing adaptive strategies of social behavior. Topics: behavioral adaptations to environment; ecological significance of spatial organizations (territoriality, coloniality, nomadism); adaptiveness of diverse mating systems (monogamy, polygamy, promiscuity); optimization of foraging strategies; predator-prey interactions; role of social behavior in population limitation.

**524 Behavioral Neurophysiology.** Small group discussions of original research papers, supplemented with lectures and demonstrations. Relationship between animal behavior and physiological properties of individual nerve cells, including sensory and central neuronal control of behavior, sensory and synaptic electrophysiology, principles of integration. Specific topics vary somewhat, partly on basis of student interests. Limited to 25 students.

**525 Behavioral Neurophysiology Laboratory.** Intensive training in analysis of simple behavior, and in neurophysiology (extracellular single unit recordings stressed). Most students work on original research projects. Limited to 12 students.

**526 Functional Organization of the Mammalian Nervous System.** Function of nervous system considered primarily from an electrophysiologic viewpoint. Important studies of reflexology, chemical

and feedback control, and comparative anatomy utilized. Laboratory studies include electrical activity of cells, reflexes, decerebrate rigidity, acoustic microphonic response, subcortical stimulation, evoked and spontaneous cortical activity.

**527 Bioelectric Systems.** 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 peripheral and central nervous systems; neural mechanisms for vision and hearing.

**528 Vertebrate Social Behavior.** Advanced seminar. The same general topics as Biological Sciences 523, but limited to graduate students with research interest in behavioral biology. To be taken in lieu of, not as sequel to, Biological Sciences 523.

**629 Advanced Topics in Neurobiology and Behavior.** Seminar provides several study groups each semester on specialized topics. Group may meet for whatever period is judged adequate to permit coverage of selected topics. Ordinarily, topics selected and circulated during the preceding semester. Suggestions for topics should be submitted to chairman of Section of Neurobiology and Behavior.

See also Psychology 323, 326, 465.

## Nuclear Science and Engineering

**IPC201 (8301) Nuclear Energy and the Environment.** Fundamentals of nuclear radiations and their measurement and interaction with matter, natural radiation environment, 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, bases of radiation protection standards (five weeks); environmental effects of nuclear electricity generation and nuclear fuel mining, processing, waste storage, control of radiation hazards, waste heat problems (four weeks).

**IPC303 (8303) Introduction to Nuclear Science and Engineering.** Introduction to low-energy nuclear physics and nuclear engineering for juniors and seniors other than those majoring in Engineering Physics. Low-energy nuclear physics and some of its practical applications. Topics: elementary quantum mechanics; properties and structure of nuclei; radiations emitted by nuclei and their interaction with matter; nuclear reactions, with emphasis on fission and fusion processes; neutron chain reaction; types

and uses of nuclear radiations, such as neutron activation analysis and radioactive tracer analysis.

**IPC609 (8309) Low-Energy Nuclear Physics.** Nuclear interaction. Properties of ground and excited states of nuclei; models of nuclear structure; alpha, beta, gamma radioactivity; low-energy nuclear reactions—resonant and nonresonant scattering, absorption, fission. At the level of *Introduction to Nuclear Physics* by Engle.

**IPC610 (8310) Nuclear Structure Physics.** 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.

**IPC612 (8312) Nuclear Reactor Theory I.** A first course in the physical theory of fission reactors. Fission process and essential properties of neutron interactions with matter. Theory of neutron diffusion, slowing down, and thermalization developed and applied to calculations of criticality and neutron flux distribution in nuclear reactors. Attention restricted to idealized configurations in order to illustrate physical ideas involved. Nuclear reaction kinetics and neutron transport theory introduced. At the level of *Nuclear Reactor Theory* by Lamarsh.

**IPC613 (8313) Nuclear Reactor Theory II.** Continuation of IPC612, primarily intended for students planning research in nuclear reactor physics and engineering. Boltzmann linear transport equation, its adjoint, and their approximate solutions developed and applied to heterogeneous neutron chain reactor. Theories of fast fission effect, resonance escape, thermal utilization developed for heterogeneous reactors. Escape probability formulation of reactor lattices, neutron importance function, perturbation theory, temperature coefficients of reactivity, fission product poisoning. At the level of *The Physical Theory of Neutron Chain Reactors* by Weinberg and Wigner.

**IPC633 (8333) Nuclear Reactor Engineering.** Selected set of topics representing 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, nuclear fuel cycles. At the level of *Nuclear Reactor Engineering* by Glasstone and Sesonske.

**IPC634 (8334) Nuclear Engineering Design Seminar.** Group design study of selected nuclear reactor system. Emphasis on safety, siting, radiation protection in design of nuclear power systems.

**IPC636 (8336) Seminar on Thermonuclear Fusion Reactors.** Present state of technological and engineering problems expected in design and construction of thermonuclear fusion reactors analyzed. Topics: basic reactor containment schemes, materials development, mechanical and heat transfer problems, refueling, radiation and safety

hazards, superconducting magnets, energy conversion, economics.

**IPC651 (8351) Nuclear Measurements Laboratory.**

Laboratory experiments plus lectures on interaction of radiation with matter and on radiation detection, including electronic circuits. Twenty different experiments available in fields of nuclear and reactor physics and radiation protection, such as: 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; properties of a subcritical assembly. Many experiments use TRIGA Reactor. Student expected to perform eight to ten experiments selected to meet needs. Some stress placed on independent work by student. At the level of *Nuclear Radiation Detection* by Price.

**IPC652 (8352) Advanced Nuclear and Reactor Laboratory.**

Laboratory experiments and experimental methods in nuclear physics and reactor physics. Ten different experiments available, among them ones using Zero Power Reactor critical facility.

## Nutrition

**Animal Science 410 Principles of Animal Nutrition.**

Principles of nutrition, involving a discussion of proteins, fats, carbohydrates, vitamins, minerals and their importance in animal nutrition.

**Animal Science 411 Principles of Animal Nutrition, Laboratory.**

Laboratory problems with animals designed to introduce student to techniques of experimentation in nutrition.

**Animal Science 505 Biochemistry of Forages and Their Utilization.**

Nutritional biochemistry of forage plants, rumen fermentation and factors influencing 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 and is responsible for planning, executing, and reporting. Application of biochemical methods to solution of nutritional problems emphasized.

**Animal Science 513 Forage Analysis.**

Nutritive evaluation of forages and related materials through various chemical and in vitro procedures. Term paper summarizing results of independent laboratory study of either materials or methods. Student may develop or provide forage materials.

**Animal Science 619, Poultry Science 619, Graduate School of Nutrition 619 Field of Nutrition Seminar.**

**Graduate School of Nutrition 550 Nutrition and the Chemical Environment.**

Students offered overall view of compounds, other than nutrients, which may be metabolized in human body. Includes natural food toxicants, food additives, water pollutants, pesticide residues, radioactive wastes, medications and drugs.

**Graduate School of Nutrition 570 Intermediate Human Physiology.**

Lectures on major functional systems of mammalian body with special reference to man. Special topics: physiology of growth, pregnancy, aging, adaptation to environmental change.

**Graduate School of Nutrition 580 International Nutrition Problems, Policy, and Programs.**

Review of food and nutrition problems, policy, programs especially as they relate to developing countries. Emphasis on need to coordinate efforts of various government ministries or departments including those of agriculture, education, economics, health, community development. Topics: planning and evaluation of applied nutrition programs; education and training in nutrition; importance of social and cultural factors; methods of increasing use of protein-rich foods; assessment of nutritional status; role of FAO, WHO, UNICEF, other agencies; action in case of famine; integration of nutrition with other projects of disease control in developing countries.

**Graduate School of Nutrition 620 General Nutrition.**

Offered to students whose principal academic training has been in a field other than nutrition. Designed to meet their need for basic but intensive introduction to principles, history, applications of nutrition.

**Graduate School of Nutrition 650 Clinical and Public Health Nutrition.**

Designed to familiarize student with some applications of nutrition to clinical and public health problems.

**Graduate School of Nutrition 660 Special Topics In Nutrition.**

For students who wish to become well informed in any specific topic selected which is related directly or indirectly to nutrition. May include individual tutorial study, experience in research laboratories, lecture series on special topic selected by professor or group of students, selected lectures of course already offered. Topics can be changed so that course may be repeated for credit.

**Graduate School of Nutrition 690 Seminar In Nutrition and Behavior.**

Examines behavioral effects of nutrition on development and cognitive learning processes.

**Graduate School of Nutrition 695 Seminar In International Nutrition and Development Policy.**

Examination from a multidisciplinary perspective of scope, nature, trends of nutrition problems, assessment of determinants of problem in particular area. Thrust is on planning and evaluation of alternative approaches required, combining macro and micro elements. Advanced graduate students working directly on nutritional problems or applying such work to other activities are welcomed.

**Graduate School of Nutrition 699 Special Topics in International Nutrition.** Designed to permit offering of courses of special interest in international nutrition. Topics can be changed so course can be repeated for credit.

**Graduate School of Nutrition 700 Nutrition Seminar.** Intended primarily for Graduate School of Nutrition students; recommended that they attend throughout year.

**Poultry Science 415 Poultry Nutrition.** Discussion of applications of principles of nutrition to feeding poultry. Feed formulations stressed, with emphasis on linear programming and computer formulation.

**Poultry Science 511 Special Topics in Nutrition.** Various topics discussed dealing with avian nutrition; to be announced before beginning of term. Students may also register for special project to obtain experience in research with avian species.

**Veterinary Pathology 931 Pathology of Nutritional Diseases.**

### Advanced Nutrition Series

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 and 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

**IO3C61 (9361) Probabilistic Models in Industrial Engineering and Operations Research.** Basic probabilistic techniques developed and applied in engineering problem areas. Topics: transform methods (particularly the z-transform and the Laplace transform); Poisson process with extensions; general birth-death process; variety of queuing and inventory models. Theoretical background and derivations included to make clear the assumptions and limitations of models and to introduce student to problems of formulation of analogous models found in engineering and operational situations.

**IO3C83 (9383) Applications of Computer Science in Industrial Engineering and Operations Research.** Application of computers in 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.

**IOD660 (9460) Introduction to Probability Theory with Engineering Applications.** Definition of probability and basic rules of probability theory. Random variables, probability distributions, 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, emphasis on queuing and inventory models.

**IOD670 (9470) Introduction to Statistical Theory with Engineering Applications.** Application of statistical theory to problems associated with analysis of data and inference drawn therefrom. Principles of statistical inference: estimating value of 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, experimentation.

**IOE512 (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.

**IOE613 (9513) Systems Engineering.** Methods of describing, analyzing, manipulating complex interrelated open systems. Graphical and mathematical analysis. Techniques of design of transportation, service, information systems and appropriate evaluation methods.

**IOE614 (9514) Facilities Location and Design.** Location and facility design models with various objective functions and under different feasibility assumptions. Mathematical programming techniques used to develop theory and methods of solution for the models discussed. Applications in industrial environmental engineering, regional planning, economics.

**IOE621 (9521) Production Planning and Control.** Methods for planning and control of large-scale operations, emphasis on manufacturing systems. Sales and production forecasting; manufacturing planning; routing, scheduling, loading; sequencing; dispatching; planning and control of inventories. Mathematical, statistical, computer methods for performing these functions. Empirical systems and procedures in use also discussed and evaluated.

**IOE622 (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, case studies.

**IOE623 (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.

**IOE626 (9526) Mathematical Models—Development and Application.**

Examination of probabilistic and deterministic models in relation to industrial engineering work. Function of models and their usefulness in analysis, synthesis, design. Application of various models, their modification to fit special circumstances, and development of new models to describe particular conditions or situations. Markov chains and dynamic programming.

**IOE627 (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.

**IOE637 (9537) Dynamic Programming.**

Optimization of sequential or multistage decision processes based upon application of dynamic programming principle of optimality. Theory, computation, applications.

**IOE640-741 (9540-9541) Network Flows and Extremal Combinatorial Programs I-II.**

Theory of flows in capacity-constrained networks and related areas in applied combinatorial mathematics. Topics: 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.

**IOE660 (9560) Applied Stochastic Processes.**

Introduction to stochastic processes, emphasis on variety of applications of basic theory. Topics: 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 drawn from queuing theory, population growth and other ecological models, inventory theory, etc.

**IOE662 (9562) Inventory Theory.** Introduction to mathematical theory of inventory and production control, emphasis on construction and solution of

mathematical models. Topics from recent technical literature considers both deterministic and stochastic demands. Dynamic programming and stationary analysis of inventory problems; renewal theory applied to inventory problems; multiechelon problems; statistical problems; production smoothing.

**IOE670 (9570) Intermediate Statistics.** Distributions used in analysis of properties of standard statistical tests, including noncentral F distributions. Power of standard statistical tests. Distributions of estimators. Rational choice of sample size. Simple, multiple, partial correlation. Regression analysis. Tests of goodness of fit.

**IOE671 (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.

**IOE672 (9572) Statistical Decision Theory.**

General problem of statistical decision theory and its applications. Comparison of decision rules; Bayes, admissible, minimax decision rules. Problems involving sequence of decisions over time, including sequential analysis. Use of sample cumulative distribution function and other nonparametric methods. Applications to problems in areas of inventory control, sampling inspection, capital investment, procurement.

**IOE680 (9580) Digital Systems Simulation.**

Use of program for digital computer to simulate operating characteristics of complex system in time. Discussion of problems encountered in construction of simulation program; synchronization and file maintenance, random-number generation, random-deviate sampling. Programming in simulation languages. Problems in design of effective investigations using simulation; statistical considerations when sampling from simulated processes.

**IOE682 (9582) Data Processing Systems.**

Design of integrated data-processing systems for operational and financial control; questions of system organization, languages, equipment appropriate to this type of application; file structures, addressing, search problems, sorting techniques; problems of multiple-remote-input, on-line data-processing systems; techniques of system requirement analysis.

**IOE690 (9590) Special Investigations in Industrial Engineering and Operations Research.**

Study, under direction, of special problems in School of Industrial Engineering and Operations Research.

**IOE725 (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.

**IOE730 (9530) Mathematical Programming.**

Dual theorem of linear programming. Geometric and algebraic characterizations of 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, stochastic programming.

**IOE731 (9531) Integer Programming.** Discrete optimization. Emphasis on linear programming problem in which variables are restricted to be integers. Theory, computation, applications.

**IOE732 (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), exterior (e.g., cutting plane) approaches.

**IOE733 (9533) Combinatorial Analysis.** Incidence systems such as block designs, finite geometries, and other combinatorial designs, counting and enumeration techniques, combinatorial extremum problems, matroids, coding theory, selected topics in graph theory.

**IOE734 (9534) Graph Theory.** Finite, infinite, directed, undirected, combinatorial, topological graphs. Connectedness, planarity and imbedding problems, enumeration problems, coloring and matching problems, automorphism group of a graph, generalizations of graphs, matrix methods, network problems. Applications to electrical networks, economics, sociology.

**IOE735-736 (9535-9536) Game Theory I-II.** Two-person-zero-sum games; minimax theorem, relationship to linear programming. Two-person-general-sum games. Noncooperative  $n$ -person games; Nash equilibrium points. Cooperative  $n$ -person games; 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.

**IOE738 (9538) Game Theory Seminar.** Seminar in which students read and report on current papers of interest in game theory, primarily in area of  $n$ -person cooperative theory.

**IOE739 (9539) Selected Topics in Mathematical Programming.** Current research topics such as mathematical programming.

**IOE761 (9561) Queuing Theory.** Definition of queuing process. Poisson and Erlang queues. Imbedded chains. Transient behavior of systems  $M/G/1$  and  $GI/M/1$ . General queue  $GI/G/1$ . Bulk queues. Applications to specific engineering problems such as shop scheduling, equipment maintenance, inventory control.

**IOE765 (9565) Time-Series Analysis.** 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 basic statistical techniques associated with models.

**IOE769 (9569) Selected Topics in Applied Probability.** Selected topics in applied probability for advanced students. Topics chosen from current literature and research areas of the staff.

**IOE773 (9573) Statistical Multiple-Decision Procedures.** Study of multiple-decision problems in which choice must be made among two or more courses of action. Statistical formulations of problems. Fixed-sample size, two-stage, sequential procedures. Special emphasis on applications to ranking problems involving choosing the "best" category where goodness is measured in terms of particular parameter of interest. Recent developments.

**IOE774 (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.

**IOE779 (9579) Selected Topics in Statistics.** Selected topics chosen from such fields as sequential analysis, multivariate analysis.

**IOE789 (9589) Selected Topics in Information Processing.** Selected topics in design of computer systems using operations research techniques.

**IOE791 (9591) Operations Research Graduate Seminar.** Weekly 1½ hour seminar devoted to presentation, discussion, 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.

**IOE793-794 (9593-9594) Industrial Engineering Graduate Seminar.** Weekly meeting to discuss assigned topics and hear presentations of state of the art from practitioners in the field.

**IOE898-899 (9598-9599) Project.** Project work requires identification, analysis, design of feasible solutions to some loosely structured systems engineering problem. Solution must be defended on sound engineering and economic grounds.

## Philosophy

**311 Modern Rationalism.**

**312 Modern Empiricism.**

**313 Medieval Philosophy.**

**314 Topics in Ancient Philosophy.**

**315 Special Topics in the History of Philosophy.**

**317 Kant and Hegel.**

**318 Twentieth Century Philosophy.**

**319 Philosophy of Marx.**

- 341 **Ethical Theory.**
- 342 **Law, Society, and Morality.**
- 361 **Metaphysics and Epistemology.**
- 381 **Philosophy of Science.**
- 382 **Philosophy of Psychology.**
- 383 **Philosophy of Choice and Decision.**
- 385 **Problems in the Philosophy of Biology.**
- 387 **Philosophy of Mathematics.**
- 388 **Social Theory.**
- 389 **Philosophy of History.**
- 390 **Informal Study.**
- 413 **Plato and Aristotle.**
- 431 **Deductive Logic.**
- 432 **Deductive Logic.**
- 433 **Philosophy of Logic.**
- 435 **Inductive Logic.**
- 436 **Intensional Logic.**
- 437 **Problems in the Philosophy of Language.**
- 441 **Contemporary Ethical Theory.**
- 442 **Problems in Ethics and Philosophy of Mind.**
- 461 **Metaphysics.**
- 462 **Theory of Knowledge.**
- 481 **Problems in the Philosophy of Science.**
- 490 **Special Studies in Philosophy.**
- 611 **Ancient Philosophy.**
- 612 **Medieval Philosophy.**
- 613 **Modern Philosophers.**
- 631 **Logic.**
- 632 **Semantics.**
- 633 **Philosophy of Language.**
- 641 **Ethics and Value Theory.**
- 661 **Theory of Knowledge.**
- 662 **Philosophy of Mind.**
- 663 **Philosophy of Religion.**
- 664 **Metaphysics.**
- 665 **Metaphysics.**
- 681 **Philosophy of Science.**

**700 Informal Study.** To be taken by graduate students only in exceptional circumstances and by arrangement made by student's Special Committee and faculty member who has agreed to direct the study.

See also Classics (courses on the Pre-Socratics, Plato, Aristotle, Lucretius, and Cicero); History (courses on the history of science); Linguistics 411-412; 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 available among subjects of mechanics, acoustics, optics, spectroscopy, electrical circuits, electronics and ionics, heat, X rays, crystal structure, solid state, cosmic rays, nuclear physics. Student expected to perform four to eight experiments selected to meet individual needs. Stress on independent work.

**520 Projects in Experimental Physics.** Projects of modern topical interest that involve some independent development work by 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 Cornell synchrotron, or with 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, radiation theory. At the level of *Classical Electrodynamics* by Jackson.

### 562 **Thermal, Statistical and Continuum Physics.**

Hydrodynamics, thermodynamics, 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. Familiarity with elementary aspects of Schroedinger equation, including its

application to simple systems such as hydrogen atom, 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, 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, emphasis on study of solids by their interactions with electromagnetic fields. Topics: sources and detectors, scanning and resonance techniques, signal-processing, sample characterization, 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 use of relativistic kinematics. Statistical analysis in design and interpretation of experiments.

**635 Solid State Physics I.** Introduction to solid state physics including studies of lattice vibrations, electronic structure of metals and insulators, with applications to electrical, thermal, transport properties. At the level of *Introduction to Solid State Physics* (4th Edition) by C. Kittel.

**636 Solid State Physics II.** Concepts developed in 635 extended and applied to survey of the following: band theory and Fermi surface in metals, localized states, magnetism, neutron and light scattering, phenomenological superconductivity.

**645 Nuclear Physics.** Properties, structure, reactions of nucleons and nuclei, emphasizing interaction between theory and experiment in developing basic ideas. Topics: nucleon-nucleon interaction; nuclear masses, moments, sizes; nuclear models; alpha, beta, gamma decay; nuclear reactions. At the level of *Nuclear Interactions*, 1964 by deBenedetti.

**646 High-Energy Particle Physics.** Physics of nucleons, mesons, strange particles from an experimental point of view. High-energy phenomena, as opposed to classical nuclear physics. 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.** Survey of topics in statistical physics such as approximation methods; scattering of light, X rays, neutrons; Boltzmann equation; phenomenological Fermi liquid theory and theory of simple fluids; introduction to Kubo formulae; superfluidity and superconductivity; computer experiments. At the level of *Statistical Physics* by Landau and Lifshitz.

**654 Theory of Many-Particle Systems.** Equilibrium and transport properties of microscopic systems of many particles studied at zero and finite temperatures. Thermodynamic Green's function techniques introduced and applied to such topics as normal and superconducting Fermi systems, superfluidity, magnetism, insulating crystals.

**657 Theory of Nuclei.**

**661 High-Energy Phenomena.** Topics of current interest in theory of strong interactions. At the level of *Dispersion Relations* by Klein.

**665 Topics in Theoretical Astrophysics.** Typical topics: solid state astrophysics, theory of stellar atmospheres, theories of interstellar medium. Topics and their treatment vary from year to year. (Usually offered in fall term of even calendar years.)

**667 Theory of Stellar Structure and Evolution.** Summary of observational facts; nuclear reactions in stars; models for static and evolving stars; very massive objects, white dwarfs neutron stars. (Usually offered in conjunction with Astronomy 560, in fall term of odd calendar years.)

**681-689 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, 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 IPB762 (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 510 Cosmology and Relativistic Astrophysics.**

**Astronomy and Space Science 530 Nuclear Astrophysics.**

**Chemistry 605-606 Advanced Inorganic Chemistry.**

**Chemistry 796 Statistical Mechanics.**

**Computer Science ICS102 (311) Introduction to Computer Programming.**

**Computer Science ICS314 (401) Introduction to Computer Systems and Organizations.**

**Computer Science ICS414 (404) Advanced Computer Programming.**

**Electrical Engineering IEE731 (4531) Quantum Electronics I.**

**Electrical Engineering IEE781 (4661) Kinetic Equations.**

**Materials Science and Engineering ITF703 (6603) Elasticity and Physical Properties of Crystals.**

**Materials Science and Engineering ITF706 (6606) Principles of Diffraction.**

**Nuclear Science and Engineering IPC609 Low Energy Nuclear Physics.**

**Theoretical and Applied Mechanics IAG672 (1772) Space Flight Mechanics.**

**Theoretical and Applied Mechanics IAG673 (1773) Mechanics of the Solar System.**

**Biochemistry 430, 431, 432 Principles of Biochemistry.**

**Biochemistry 531-532 Intermediate Biochemistry.**

## Physiology

**Biological Sciences 414 Mammalian Physiology.** General course. Circulation, respiration, digestion, metabolism, renal function, endocrinology, nervous system.

**Biological Sciences 427 Sensory Function.** Sensory receptors and central nervous system transformation of afferent activity considered in relation to human and animal psychophysical data and to adaptive significance of behavior. Receptors examined in terms of anatomy, biochemistry, biophysics of transduction, the central nervous system control of peripheral input. Information and signal detection theories applied.

See also Animal Science 427, 451; Veterinary Medicine 722, 724, 726, 727, 750, 751, 752, 753, 757; Botany 547.

## Plant Breeding and Biometry

**503 Methods of Plant Breeding.** Breeding systems for producing possible crop variety forms. Laboratories include controlling pollination, producing heritable variation, selection techniques with emphasis on disease resistance. A Saturday field trip to the N.Y. State Agricultural Experiment Station at Geneva, N.Y.

**505 Physiological Genetics of Crop Plants.** Genetic, biochemical, molecular mechanisms controlling plant variation in physiological phenomena such as photosynthesis, respiration, translocation, self-incompatibility, male sterility, seed dormancy, yield, heterosis. 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. These genetic, physiological, biochemical, environmental phenomena presented from data obtained through studies with higher plants. Emphasis physiological variation that can be exploited in plant breeding.

**507 Research Orientation.** Designed to acquaint student with various facets of research in plant breeding. Particular attention given to concepts, philosophies relating to plant research, oral and written communication procedures in research.

**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.** Designed for study in depth of advanced research and other topics of special relevance to plant genetics and breeding. Research topics: somatic hybridization, host-pathogen relationships, breeding for disease and insect resistance, parameters of yield, mutation or radiation breeding, uses of male sterility, world germ-plasm resources, mass selection, plant competition, population dynamics.

**550 Special Problems in Research and Teaching.** Undergraduates must attach to their preregistration material, written permission from staff member who will supervise work and assign grade. Members of the departmental staff.

**622 Seminar.** Members of departmental staff and graduate students.

## Statistics and Biometry

**200 Statistics and the World We Live In.**

**408 Probability and Statistics I.** Introduction to theory of probability models, random variables, probability distributions, generating functions, limit theory; biological and statistical applications serve to motivate the presentation.

**409 Probability and Statistics II.** Concepts developed in 408 applied to provide introduction to theory of statistical inference. Topics: decision theory, sufficiency, estimation, hypothesis testing and linear regression. Biological applications again serve to motivate presentation.

**411 Stochastic Models in Biology.** Introduction to stochastic processes in biology. Necessary mathematics and statistics 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 discussed and applied. Special emphasis given various processes applied to genetics.

**412 Deterministic Models in Biology.** Introduction to deterministic mathematical models in biology.

Application from biological viewpoint. Necessary mathematics introduced as needed. Finite differences, differential equations, logistic, growth and decay, other deterministic models corresponding to those introduced in 411.

#### **417 Matrix Algebra in Biology and Statistics.**

Basic matrix algebra with applications in biology, business, economics, statistics. Arithmetic procedures and other matrix operations; determinants, rank and linear independence, latent roots and vectors, solving linear equations, generalized inverses, direct sums and products. Use of matrices in regression analysis and linear statistical models.

**510 Statistical Methods I.** Use of probability models to portray variations of observations arising through experimentation in biology and other fields. Particular attention given to binomial, Poisson, and normal probability models. Techniques developed for utilizing information contained in observations arising from specific population to make inferences about characteristics of population. Topics: point and interval estimation, tests of hypotheses, inference for a single population, comparisons between two populations, regression and correlation analysis, one-way analysis of variance. Both parametric and nonparametric procedures discussed. 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.** Work of 510 continued. Topics: multiple and curvilinear regression, complex analysis of variance and covariance. Analysis of variance discussion considers treatment designs, single degree of freedom contrasts, simpler experimental designs, sampling errors, fixed, mixed random models, the effect of disproportionate numbers.

**513 Design of Experiments I.** Principles and techniques of experimentation, theoretical concepts, extensions and variations of the completely randomized, randomized complete block, latin square designs, factorial experiment and confounding, fractional replication including response surface designs, lattice designs, crossover designs, augmented and other designs, covariance analyses, error rates, tests and interval estimation for ranked means, sample size, variance component analyses, unequal number analyses, place of orthogonality in design, advanced statistical methodology under various fixed, mixed, random models.

**514 Design of Experiments II.** Continuation of work in 513, emphasis on role of confounding in experimental and treatment designs. Generalized forms of analyses and construction presented followed by 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, related topics.

**517 Linear Models.** Introduction to multinormal variables and distribution of quadratic forms; linear statistical models, estimable functions, testable hypotheses; regression models, experimental design models, variance components models, combinations thereof.

**518 Special Topics in Biometry.** Topics selected from list including principles and methodology of bioassay, discriminant functions, sequential analysis, nonparametric methods, mark-recapture methods, statistical genetics.

**520 Design of Experiments III.** Mathematical development of properties, construction, analysis of experiment and treatment designs. Proofs given for known results and problems formulated in mathematical terms.

## Plant Pathology

**301 General Plant Pathology.** Introduction to nature, cause, control of disease in plants. Representative diseases of cultivated crops studied in the laboratory.

**309 Comparative Morphology of Fungi.** Introduction to mycology. Emphasis on morphology rather than taxonomy.

**501 Advanced Plant Pathology.** Basic principles and techniques of science of phytopathology. Provides an adequate foundation for research in this area.

**502 Principles of Plant Disease Control.** Emphasis on philosophies underlying principles of plant disease control. Helps students interested in plant protection to 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.** Provides advanced graduate students with basic information on plant viruses and on diseases they cause.

**506 Plant Nematology.** Anatomy, morphology, taxonomy of plant parasitic forms and nonparasitic soil-inhabiting forms of nematodes. Plant pathogenic forms considered from standpoint of host-pathogen relationships, host ranges, life cycles, symptoms they cause. Principles and methods of control discussed.

**507 Bacterial Plant Pathogens.** Provides basic information on bacterial plant diseases and phytopathogenic bacteria. Laboratory includes some more important techniques used in study of bacterial plant pathogens.

**508 Disease and Pathogen Physiology.** Provides students with insight into mechanisms of pathogenesis and altered metabolism of diseased plants.

**521 Experimental Methods in Plant Pathology.**

Basic information on 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 stressed in areas such as physiology, developmental morphology, genetic systems, or cytotoxicity. 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 concepts of plant pathology as they relate to basic and applied research problems, teaching, extension.

**556 Advanced Plant Nematology.** Students 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, evaluation of control practices. This research intended to broaden training in plant nematology and thus projects selected do not duplicate thesis research.

**579 Advanced Mycology.** Detailed study of biology and taxonomy of major groups of plant pathogenic fungi (rusts, smuts, Fungi Imperfecti, Peronosporales), emphasis on mechanisms of variation in fungi. Optional field trips.

**599 Taxonomy of Fungi.** Emphasis on principles of taxonomy and nomenclature, critical evaluation of keys and monographs, practice in identification. Discomycetes, from which most examples are drawn, treated in detail. Required field trips.

**645-654 Current Topics.** Weekly discussions of current topics in special areas of plant pathology and mycology. Students 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 Cytology of Plant Disease.**

**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.** Comprehensive study of sources of knowledge and practices in pomology. Results of experience and research pertaining to pomology discussed, with special reference to their application in solution of problems in commercial fruit-growing.

**501 Special Topics in Experimental Pomology.** Selected topics considered with respect to current literature and/or experimental techniques. Topics reflect research interests of several professors who participate.

**502 Research.**

**504 Growth and Development of Woody Plants.** Advanced course on growth and development of woody plants. Physiological responses emphasized, but morphological and biochemical changes also considered.

**600 Seminar.** Required of students taking 502, and graduate students in pomology.

## Psychology

**303 Learning.** Fundamental conditions and principles of learning, with emphasis on basic phenomena of classical and operant conditioning. Traditional and contemporary theories of learning reviewed, selected experimental literature discussed with special emphasis upon recent developments in the field.

**304 Learning Laboratory.** Experiments performed in laboratory illustrate equipment and techniques commonly used in studies of learning. Although some experiments involve human subjects, most are performed with rats or pigeons. Proposal for an original experiment required, and should include review of research literature on which proposal is based.

**305 Visual Perception.** Basic phenomena of visual perception in terms of the stimulus variables on which they depend and the mechanisms involved. Topics: perceptual constancy, illusions, space perception, motion, elementary visual mechanisms, pattern recognition, some problems of perceptual learning and development.

**307 Motivation.** Factors controlling initiation, direction, intensity of activity. Methods of research, emphasis on experimental and statistical controls.

Evaluation of evidence on major theories of motivation such as field theory, psychoanalysis, behavioristic drive theory.

**309 Development of Perception and Attention.**

Comparison of major theories of perceptual learning and problems they focus on, such as perceptual skills, cross-modal equivalences and effects of early rearing conditions. Development in children of perception of objects, spatial layout, pictures, symbols. Trends in perceptual development.

**310 Human Learning and Memory.**

Basic process of human learning and memory, particularly for simple verbal material. Emphasis on storage and retrieval of information as fundamental unit of learning.

**313 Cognitive Processes.**

Concentrates on higher thought processes such as problem solving, concept formation, thinking, theories of thinking, mathematical models, computer simulation of thought processes. Students expected to carry out small empirical research project on some problem in this area.

**316 Auditory Perception.**

Basic phenomena of auditory perception studied with emphasis on music and speech. Topics in foundations of auditory perception: loudness, pitch, masking, binaural localization, elementary neurophysiology of auditory pathway followed by an examination of perceptual bases of harmony, melody, rhythm. Topics in speech: rudiments of acoustic phonetics, natural and synthetic mechanisms of speech production, theories of speech perception, auditory coding of sound.

**322 Physiological Psychology Laboratory.**

Experiments done on physiological aspects of conditioning and memory in vertebrates and invertebrates, interactions between hormones and behavior, effects of brain lesions on perceptual and alimentary behavior. A final original experiment planned and carried out.

**323 Physiological Psychology.**

Selective examination of neural, endocrine, and bio-chemical functions related to emotion, memory, learning, sleep.

**324 Existential Psychology.**

Approach to study of man with underlying assumptions and methods of inquiry different from those based upon natural scientific model. Part I: introduction to work of a number of philosophers and psychologists in European existential tradition—Binswanger, Kierkegaard, Heidegger, Sartre. Part II: contemporary existential psychology and psychiatry, focusing on R. D. Laing and various influences on his work. Topics: philosophical and methodological foundations of natural scientific and existential-phenomenological approaches to man; psychologies as belief systems and world views as human phenomena; person's experience of and action in his world; approaches to interpersonal and group relations; individual's world in relation to his culture; sanity and madness.

**325 Introductory Psychopathology.**

Introduction to study of various forms of psychopathology especially as they relate to experiences of human growth and

development. Major syndromes, investigations, theories of etiology, and approaches to treatment. Provides students with opportunity to explore their own life experiences and life experiences of others as they play a role in psychological health, growth, disturbance, self defeat.

**326 Comparative Psychology.**

Communication and social behavior of animals. Topics: nature and function of animal signals, development of social behavior in individuals, courtship, mating, parental behavior, fighting, evolution of communication systems and social organization. Laboratory is integral part of course and provides opportunity to observe and describe behavior of several different species and to learn several methods of recording behavior for quantitative analysis.

**328 Behavioral Maturation.**

Emergence of behavior studied in light of developmental biology, including behavior genetics, neuroembryology and morphogenesis, physical maturation of brain, transformation and allometry.

**345 Afro-American Perspectives in Experimental Psychology (Africana Studies 345).**

Critical examination of representative sample of philosophical presuppositions, methodologies, data, theories in experimental psychology that pertain directly to black Americans. Emphasis on (1) sensitizing people to issues as they are viewed from black perspective, (2) developing research strategies consistent with this perspective. Viability and feasibility of independent black psychology seriously entertained. Combines student presentations, instructor's lectures, guest speakers. Optional one hour a week problem-solving session in research design and methodology also offered.

**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.

**355 Man and Computer.**

Recent efforts toward making computer do intelligent tasks studied in relation to models of human behavior. These tasks include understanding of English, comprehending speech, recognition of visual form, problem solving, learning. Particular emphasis on use of computer in modeling human cognitive processes and ways in which computer may aid and participate in decision making. Some discussion devoted to computer impact on society including threat to privacy and meaningful work.

**361 Drugs and Behavior.**

Techniques and problems in experimental psychopharmacology as they relate to psychoactive drugs and behavioral, biochemical, physiological effects of these drugs. Social and legal issues relating to use of drugs in human societies.

**372 Psychology of Play and Sport.**

Investigation of theoretical and empirical issues regarding behavior of play, sport, games with special attention directed to aggression, competition, psychopathology. Developmental, social-psychological, motivational

perspectives applied, and contributions from sociology and anthropology considered.

**380 Role Theory (Sociology 380).** Traditional perspectives on social roles integrated with current research on specific roles. Topics: role as a concept linking society and individual; symbolic interaction; socialization processes; role-taking; self identity; occupational roles; sex roles; role networks. Methods of studying social roles examined.

**381 Social Psychology (Sociology 381).** Analysis of history, concepts, methods, theories used to describe and conceptualize ways in which people react to one another in social settings and in the laboratory. Students work individually or as teams on projects, using experimental or other empirical methods. Topics: socialization, attitude change, communication, interpersonal influence, impression formation, leadership, propaganda.

**383 Social Psychological Aspects of Social Change (Sociology 383).** A number of social psychological theories of social change critically compared and discussed. Attempt made to examine utility of various theories of social change and social stress for understanding contemporary social phenomena.

**385 Theories of Personality (Sociology 385).** Critical survey of modern theories of personality. Analysis of relation of personality theory and related research to social sciences, psychology, literature. Emphasis on normal personality, and clarifying hypotheses for systematic empirical testing.

**387 Psychological Aspects of Political Behavior (Sociology 387).** Survey concerning (1) political personalities and personality types, e.g., Nixon, Wilson, Republicans, Democrats, Machiavellians, dogmatists, paranoids, and active positives vs. negatives; (2) political motivation, e.g., neurotic power and esteem needs; (3) social movements, e.g., student activism, liberation groups; (4) political attitude polarization and change; (5) psychocultural theories of politics and war derived from Maslow, Freud, Marx, Weber, Fromm.

**401 Psychological Testing.** Emphasis on logical and mathematical problems in interpretation, evaluation, construction of tests. No training given in administering tests.

**416 Psychology of Language.** Advanced treatment of nature of human capacity for language. Topics: nature of linguistic theory, semantics and reference, language universals, speech perception and production, comparative primate vocalization/communication, relationship of language to other cognitive processes, embodiment of language in brain.

**420 Principles of Neurobiology Laboratory (Biological Sciences OBC420).** Laboratory practice with neurobiological preparations and experiments, designed to teach students techniques, experimental designs, research strategies used to study biophysical and biochemical properties of excitable membranes, sensory receptors, central nervous

system transformation of afferent activity, characteristic composition and metabolism of neural tissue. Part I (approximately eight weeks): fundamental techniques learned and used in experiments by all students; Part II (approximately eight weeks): students learn and use more specialized techniques for experiments in either elementary neurophysiology of excitable membranes, or sensory function, or neurochemistry.

**424 Brain and Behavior (Biological Sciences OBC424).** Theoretical introduction to human neurology for students of behavior. This survey of clinical symptoms and their etiology is designed to enable students to make use of diseases for research purposes.

**426 Seminar and Practicum in Psychopathology.** Fieldwork and seminar course for advanced students who have mastered fundamental concepts of personality theory and psychopathology. Provides opportunity for student to explore in depth various forms of psychopathology, their etiology and treatment, to discuss and evaluate these in seminar, and under close supervision, to work with mental health professionals and those who seek their help in several mental health settings.

**427 Sensory Function (Biological Sciences OBC427).** Sensory receptors and central nervous system transformation of afferent activity considered in relation to human and nonhuman behavior and to adaptive significance of behavior. Receptor examined in terms of anatomy, biochemistry, biophysics of transduction, central nervous system control of peripheral input.

**440 Sleep and Dreaming.** Investigation of animal and human biological, physiological, psychological research on sleep and dreaming. Explores relationship between physiological evidence, empirical laboratory research, clinical findings in process and content of dream state. Demonstrations of research techniques used in animal and human sleep laboratory. Seminars focus on reviews of literature and research design and proposals.

**442 Physiological Mechanisms of Animal Social Behavior.** Examines intricate relationships between environmental, behavioral, physiological factors in causation of social behaviors (e.g., sexual behavior, competition and aggression, maternal behavior, social organization). Hormone, neurohormonal, brain functions related to these behaviors. Broadly comparative and covers both psychological and ethological approaches.

**444 Theories of Human Behavior.** Devoted to comparative study of several major theories of human behavior including Heider's naive psychology, Lewin, Freud, Piaget, several varieties of S-R theory. Students read original material in each theory, and also sample empirical studies that have stemmed from each theory.

**445 Research Excursions in Black Psychology.** In-depth probe of selected topic in psychology that pertains directly to black Americans with heavy emphasis on research process. Revolves around five

major concerns: (1) critically appraising relevant research and theorizing already in existence; (2) advancing alternative conceptual models whenever necessary; (3) formulating rigorous and heuristic research paradigms; (4) discussing implications and applications for community level programs and institutions; (5) developing practical yet analytical understanding of research design, methodology, the dynamics of problem selection and data inference.

**464 Motivation and Human Learning.** Problems in initiation and control of learning behavior. Review of classical and current learning theories; emphasis on motivational constructs. Survey of research on intentional and unintentional learning, cognitive and noncognitive factors in conditioning, motivational factors in intellectual learning, motor skill, memorizing.

**465 Mathematical Behavior Theory.** Brief overview of current developments in mathematical psychology; techniques for application of mathematics to psychological theory. Topics: choice behavior, decision theory, psychophysics, memory and learning theory, information processing models of behavior.

**467 Seminar: The Examined Self: A**

**Psychohistorical View.** Study of American biographical literature which provides material for analysis of changing views of selfhood in historical context. Texts studied as illustrating both ideology of the period and as samples of persistent problems of self development; focus on personal involvement with text.

**469 Seminar: Psychotherapy: Its Nature and Influence.** Small discussion seminar on nature of psychotherapy in terms of communication of affect, both verbally and nonverbally, within psychotherapeutic situation. Focus primarily on dyadic relationship, but comparison to family, group, play therapy discussed. Issues related to therapeutic goals, differing views of nature of man, ethical concerns and research problems also considered. General orientation ego-analytic and humanistic.

**471-472 Statistical Methods in Psychology.**

Analysis of methods for treating various kinds of psychological data. Fall term: probability and treatment of frequency data; tests of significance, confidence limits, other methods of statistical inference; parametric and nonparametric tests. Spring term: analysis of variance and treatment of complex experimental designs; linear, curvilinear and multiple regression, correlation.

**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 drawn primarily from behavioral genetics; political behavior, cross-cultural studies, nonlaboratory areas. Little emphasis on

computational procedures since standard computer programs used for most techniques discussed.

**480 Attitude Theory (Sociology 480).**

**481 Advanced Social Psychology (Sociology 481).** Selected topics in social psychology examined in depth, with emphasis on experimental research. Readings consist for the most part of original research reports. Topics: social comparison theory, social and cognitive determinants of the emotions, cognitive dissonance, attribution processes, interpersonal attraction, aggression, altruism, and compliance, research methods in social psychology.

**483 Social Interaction (Sociology 483).** Field and laboratory. Major dimensions of interpersonal perception and behavior and their relation to self-conception, social roles, group structure, dynamics. Contemporary research stressed in readings. Student projects an integral part of course.

**484 Experimental Group Dynamics (Sociology 484).** Study of experimental design and methods in social psychology. Students design, conduct, analyze an empirical research project in the area of interpersonal relationships, person perception, social influence or group dynamics.

**485 Individual Differences (Sociology 485).**

Survey of research literature in differential psychology on personality, intelligence, creativity, psychopathology, sex, race. Conflicts between experimental, i.e., manipulative and correlational research approaches considered in terms of both their "relevance" and scientific quality. Also, general problems in personality assessment.

**486 Socialization Processes and Social Context (Sociology 486).** Seminar critically examines existing theory and research on role of groups in shaping behavior and values of their members. Particular attention focused on such processes as modeling, social reinforcement, pressure to conform in enduring social structures such as family, peer group, work teams, business organization. Students expected to work independently in assembling and evaluating material relevant to particular issues.

**487 Selected Problems in Psychopathology and**

**Society (Sociology 487).** Focuses on one or two select topics related to personality, situational and social structural aspects of psychopathology, maladaptive behavior. Topics in general area of sociocultural stress, social psychiatry, specific problem areas such as alcoholism, drugs, with major focus on psychoactive drugs and alcoholism. Intended for advanced undergraduates and graduate students, will have strong emphasis on critical examination of relevant empirical research.

**489 Seminar: Selected Topics in Social Psychology (Sociology 489).**

Small discussion seminar dealing with issues in both social and personality psychology. Fall term: initial discussions focus on specific areas such as interpersonal evaluation, attitude change, group processes. Later, discussions 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.

- 492 Psychology and Ethics.**
- 496 Supervised Study.**
- 497 Supervised Study.**
- 511 Perception.**
- 513 Learning.**
- 515 Motivation.**
- 517 Language and Thinking.**
- 521 Psychobiology.**
- 523 Physiological Psychology.**
- 525 Mathematical Psychology.**
- 531 History of Psychology.**
- 541 Statistical Methods.**
- 543 Psychological Tests.**
- 545 Methods in Social Psychology.**
- 547 Methods of Child Study.**
- 561 Human Development and Behavior.**
- 575 Personality.**
- 577 Industrial Psychology.**
- 580 Experimental Social Psychology (Sociology 580).**
- 584 Proseminar in Social Psychology (Sociology 584).**
- 585 Social Structure and Personality (Sociology 585).** Discussion seminar examining impact of structural factors on personality development, and on ways in which individual internal states and behavior patterns affect functioning of social systems.
- 591 Educational Psychology.**
- 595 The Teaching of Psychology.**
- 682 Social Psychology (Sociology 682).**  
Research-oriented analysis of selected topics in social psychology.
- 683 Research Practicum in Social Psychology (Sociology 683).**
- 684 Seminar in Feminine Identity (Sociology 684).**
- 690 Nutrition and Behavior (Graduate School of Nutrition 690).**

## Regional Science

Descriptions of the following courses may be found in the Fields with which they are identified.

### **Agricultural Economics 450 Resource Economics.**

### **Agricultural Economics 712 Quantitative Methods I.**

### **Agricultural Economics 650 Economic Analysis of Public Resource Investment.**

### **Economics 517 Intermediate Mathematical Economics.**

### **Economics 518 Intermediate Mathematical Economics.**

### **Economics 619a-620a Workshop in Econometrics.**

### **Industrial and Labor Relations 710 Economic and Social Statistics.**

### **Public Policy and Regional Analysis 733 Planning Analysis.**

### **Public Policy and Regional Analysis 751 Planning Information Systems.**

### **Public Policy and Regional Analysis 830 Planning Public Investments.**

### **Public Policy and Regional Analysis 853 Planning and Evaluation of Environmental Health Programs and Projects.**

### **Public Policy and Regional Analysis 863 Regional Planning and Development in Developing Countries.**

### **Public Policy and Regional Analysis 916-917 Advanced Seminar in Urban and Regional Theory I, II.**

### **Public Policy and Regional Analysis 930 Seminar in Methods for Planning and Policy Analysis.**

### **Public Policy and Regional Analysis 963 Planning Techniques for Developing Regions and Small Nations.**

### **Regional Science 501 Introduction to Regional Science.**

### **Regional Science 511 Intermediate Regional Science.**

### **Regional Science 521 Urban Design Economics (Introductory).**

**Regional Science 769 Location Theory.** Traditional Weberian location doctrine. Transport orientation, labor orientation, agglomeration, urban rent theory. Interregional trade and market and supply area analysis. Particular to Loschian and Christaller systems of urban places. Dynamic aspects of location and urban theory, with emphasis on changing location and spatial distribution patterns.

**Regional Science 771 Methods of Regional Analysis.** Advanced application of interregional and regional input-output and linear programming techniques to development problems. Application of spatial interaction and growth (intertemporal) models to the analysis of urban and multiregion systems, with particular reference to environmental quality management.

**Regional Science 781 Conflict Analysis and Management in Regional and Multiregional Systems.** Conflict problems in regional planning and development as they arise in single and multiregional systems. Such systems may comprise part or whole of a nation, or may consist of nations which form world region groupings. Concepts such as equity, strategy, prominence examined and processes such as coalition formation and determination of joint-policy demands in interdependent decision situations. Increment and other cooperative procedures explored for their relevance.

**Regional Science 790 Seminar on Selected Topics in Regional Science.** Presentation of research papers by faculty and students on selected topics in regional science. Recent emphasis on models for regional development policy, management of regional air systems.

**Urban Planning and Development 821 Seminar in Regional Development Models.**

**Urban Planning and Development 822 Seminar in Regional Interindustry Analysis and Programming.**  
**Urban Planning and Development 824 Econometric Methods in Regional Planning.**

## Romance Studies

### French

- 309 Modes of the French Novel.
- 361 Mollère.
- 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 Theatre.
- 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

- 243 Seminar in Jewish and Islamic Philosophy.** Metaphysical and sociopolitical thought of Maimonides and of al-Farabi, a leading Muslim philosopher who exercised considerable influence upon Maimonides. Views of these two thinkers discussed against background of Greek philosophy and some prevalent medieval social concepts. All readings in English.
- 330 The Literature of Ancient Israel I.** The Old Testament.
- 331 The Literature of Ancient Israel II.** Several later books of Old Testament, Apocrypha, Dead Sea (Qumran) Scrolls. Ancient Israelite beliefs and cultural assumptions needed to comprehend texts as literature. All readings in English.
- 333 Biblical Law.** Study of biblical laws, proverbs, narratives, against background of ancient Near Eastern law and custom.
- 334 Studies in Christian Origins.** Religious and moral ideas, customs, conventions which appear in New Testament traced in Old Testament and other Jewish writings.
- 336-337 The Book of Jeremiah.** Exegesis and literary analysis of Hebrew text.
- 341 A Synoptic Course of the History of the Jewish People (1492-1967).** General survey of major social and political developments in Jewish history from beginning of modern era to Six-Day War. Topics: struggle for Jewish emancipation; spread of Religious Reform movement; rise and development of anti-Semitism; growth of modern Jewish nationalism; the holocaust and establishment of State of Israel.
- 360-361 Seminar in Contemporary Hebrew Literature in Israel.** Analysis of selected works which combine ideological and personal responses

to traumas of war and statehood. Poetry of Uri Zvi Greenberg and Hayyim Guri and novels of Moshe Shamir and Avraham B. Yehoshua. English translations available.

## Slavic Studies

**131S-132S Elementary Course in Slavic Languages.** In a given year one of the following languages is offered according to demand: Serbo-Croatian, Bulgarian, Slovenian, Polish, or Czech.

### 301-302 Advanced Russian Morphology and Syntax.

**312 Background of Russian Culture.** Patterns and evolution of Russian culture from earliest times to present. Topics: folklore and folk art; mythology; customs, traditions and social organization of pagan society; Christianization of Russia; theology and ecclesiastical organization; trade; relations with neighboring cultures; life in medieval Russia; contact with the West; development of urban and commercial classes; social life and material structure of Russian people from middle of nineteenth century until today.

**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 Theatre and Drama.** Survey of history of Russian drama from eighteenth century to present: Fonvizin, Griboedov, Gogol, Ostrovsky, Chekhov. Soviet dramatists. Conducted in English, but reading knowledge of Russian required.

### 335 Gogol.

**336 Society and Literature.** Rise of realism in Russia, considered in context of both social and literary history. Attention to non-Russian parallels. Reading in translation: Lermontov, Chernyshevsky, Dostoevsky, Turgenev.

**367 The Russian Novel in Translation.** Works by Turgenev, Dostoevsky, Tolstoy, others.

**368 Soviet Literature in Translation.** Introduction to selected works of Russian literature, from 1917 to date, examined as works of art and as social and historical documents.

**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, structure of his novels, his importance for modern European literature. Reading in translation, but graduate students do a portion of reading in Russian.

**380 Solzhenitsyn and Siniavsky.** Reading and discussion of chief works of Solzhenitsyn and Siniavsky in English translation. For those reading Russian, extra meetings held in which shorter works are read and gone through in the original.

Examination of two divergent trends in contemporary Russian prose fiction—realism and fantasy.

**401-402 History of the Russian Language.**

**403 Linguistic Structure of Russian.** Descriptive study and analysis of Russian linguistic structure. Russian phonetics, phonemics, morphology, syntax.

**404 Russian for Teachers.**

**431 Russian Prose Fiction.**

**432 Pushkin.**

**499 Origins of the Avant Garde.** Discussion of selected topics concerning development of an aesthetics of modernism. Topic: Novels of consciousness: Bely, Joyce, Woolf, Pasternak, others.

**501 Old Church Slavic.**

**502 Old Russian.**

**528 Topics in Soviet Literature.** Survey of major periods, figures, movements of Soviet period with emphasis on those theoretical and historical problems fundamental to period as a whole. Early Soviet literature and prerevolutionary literary movements; 1920s as avant-garde period; ideological controversy and writers' groupings; unnoticed 1930s; place of emigre literature; theory of socialist realism and science of thaw measurement.

**534 Topics in Russian Symbolism.**

**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 basic structures of Slavic languages.

**604 Seminar in Application of Linguistics to Analysis of Slavic Literature.** Specific topics to be chosen according to students' needs.

**611 Supervised Reading and Research.**

**617 Russian Stylistics.** Literary uses of Russian language. Close examination of texts from various periods and genres. Practical exercises.

**618 Russian Stylistics.**

**620 Studies in Russian Poetry.** Extensive reading of nineteenth- and twentieth-century poets. Two or three poets selected for class as a whole; each student works privately on another poet of his choice. Reports, papers, readings of important critical works (such as Eikhenbaum's *Melodika russkogo stikha*).

**621 Russian Literature from the Beginnings to 1700.** Representative works of Old Russian literature studied in context of cultural and artistic life of times. Topics: integration of the arts; Kievan Rus as participant in pre-Renaissance; representative genres; creation of Muscovite culture; polemical literature.

**622 Eighteenth-Century Literature.**

**623 Early Nineteenth-Century Literature.**

1800-1825: Early Russian romanticism, Zhukovskii, Batiushkov, Delvig, Baratynskii, Rylev.

**624 Mid-Nineteenth-Century Literature.**

Continuation of 623. Covers period from 1825-1850. Emphasis on journals and prose of 1830s and 1840s. Belinskii, Lermontov, Nadezhdin, Vel'tman, V. F. Odoevskii, Polevoi, Zagoskin.

**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.

**700 Seminar in Slavic Linguistics.**

**701 Introduction to Graduate Study.** Required of all first-year graduate students majoring in Russian literature. Bibliography, methods of literary analysis, stylistics, topics in scholarship.

**Linguistics 671-672 Comparative Slavic Linguistics.**

## Sociology

**402 Social Theory.** Survey of selected theories and concepts in contemporary sociology reviewed in historical perspective, in relation to contributions of other social sciences, and in terms of present-day developments in theory and research. Emphasis on trends in contemporary social theory.

**403 Sociology of Science and Technology.** Critical study of data relating to relationship between scientist and society. A number of studies dealing with scientific creativity, organization, political structure examined for insight into the institutional and power base of science. Emphasis on expanding role of technology and technologist as they affect quality of life, social organization, power in society.

**420 Mathematical Sociology I.** Elementary mathematics as applied to sociological theory. Both deterministic and probabilistic models considered. Stochastic probability processes 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*.

**434 Sociology of Human Fertility.** Review of major literature dealing with social causation of variation in human fertility. Emphasis on international comparisons and methodology of field research.

**435 Mortality and Morbidity.** Interrelationships between structure of society and duration of life and incidence of illness. International comparisons and differences between groups in the United States.

**438 Human Migration.** Analysis of international and internal migration as it affects social and economic structure of societies and the groups in movement.

Major theoretical and methodological investigations examined.

**441 Structure and Functioning of American Society I.** Systematic analysis of major institutions of kinship, stratification, economic activity, political structure, education, religion. Values and their interrelations in modern social order and deviance and evasion. Survey of more important types of groups and associations making up a pluralistic nation.

**442 Structure and Functioning of American Society II.** Study of interrelation of institutions, including analysis of regulation of economic and political systems. Group cooperation and conflict surveyed. Analysis of important processes of change in institutions, values, social organizations.

**447 Sociology of Health and Medicine.** Critical overview of many complex issues involved in delivery of medical care. Topics: medical epidemiology, medical care in communist world, development of U.S. medicine, organization of health care in U.S. now and in future, doctor-patient relationship, medical education, paraprofessionals, preventive medicine, special topics as appropriate.

**462 Survey Research Methods.** Models of explanation and images of man underlying current survey methods.

**470 Urban Research Methods.** Problems and methods of analysis in urban research. Topics: urban boundaries, functional classification of cities, measures of segregation and urbanization, estimation of internal migration, urban trend analysis, social area analysis and causal analysis. Use of U.S. census tapes encouraged for projects. (Additional hours on computer programming available to students desiring this option.)

**472 International Urbanization.** Examination of processes and prospects of urbanization in international context. Growth, nature, roles of urban centers in both developed and developing nations. Urbanization viewed from an interdisciplinary perspective.

**480 Attitudes and Attitude Change (Psychology 480).** Systematic survey of theory and research on attitudes and attitude change.

**481 Advanced Social Psychology (Psychology 481).** Selected topics examined in depth, with heavy emphasis on experimental research. Readings consist for the most part of original research reports. Topics may include: social comparison theory, social and cognitive determinants of emotions, cognitive dissonance, attributive processes, interpersonal attraction, aggression, altruism and compliance, research methods in social psychology.

**483 Social Interaction.** Field and laboratory. Major dimensions of interpersonal perception and behavior, and relation to self-conception, social roles, group structure, dynamics. Contemporary research stressed in readings. Student projects an integral part of course.

**485 Individual Differences (Psychology 485).** Survey of research literature in differential psychology on personality, intelligence, creativity, psychopathology, sex, race. Conflicts between experimental, i.e., manipulative, and correlative research approaches considered in terms of both their "relevance" and scientific quality. General problems in personality assessment.

**486 Socialization Processes and Social Context (Psychology 486).** Critical examination of existing theory and research on role of ecological factors in socialization process. Particular attention to interplay between different socialization systems (e.g., family, peer group, work setting, political system) and differential effect of varying socializing agents (e.g., parent, teacher, boss, coworker). Students expected to work independently in preparing critical reviews of relevant research literature and developing designs for needed research.

**489 Seminar: Selected Topics in Social Psychology (Psychology 489).** Topics vary from year to year. Information can be obtained for any year from the Department offices.

**522 Philosophy of Social Research.** Dialectical versus positivistic social research. "Value freedom" controversy. Objects of social analysis with implications for research strategies. A paradigm of scientific process. Measurement, experimentation, quasixperimentation.

**523 Foundations of Statistical Analysis.** Logic of social research; sets and relations; measurement; probability models.

**524 Research Design and Statistical Inference.** Logic of statistical inference, experimentation, 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 evaluated in detail as models of human mobility.

**528 Measurement and Latent Structure Theory.** Problem of index construction and classification is focus for study of factor analysis, latent structure analysis, nonmetric multidimensional scaling procedures. Emphasis on logic of models and their relations to social theory and data. Computer routines used.

**530 Introduction to Social Demography.** Survey of methods, theories, and problems of contemporary demography. Special attention to social determinants and consequences of fertility, mortality, migration. Populations of both developed and developing areas examined.

**531 Demographic Theory.** Theory construction, hypothesis derivation, integration of theory and research in demography. Emphasis is on contemporary theories. Earlier formulations beginning with Malthus also examined insofar as they deal with

fertility, mortality, migration, people-resource question.

**535 Techniques of Demographic Analysis.**

Methods of processing and analyzing demographic data. Measures of mortality, fertility, migration as applied to census and vital statistics data analyzed, and 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. Field survey techniques, including sampling and questionnaire construction, and formal demographic analysis. Students work on selected research projects.

**541 Social Organization and Change.** Analysis of major problems in theory and research in general field of social organization and change. Subject studied from standpoint of nature and size of social system (small groups, communities, large organizations, societies) and also in terms of its social processes and properties (integration, authority, conformity, deviance).

**583-584 Proseminar in Social Psychology.** Critical analysis of major current theories and research. Specific topics vary from year to year.

**585 Social Structure and Personality (Psychology 585).** Discussion seminar examining impact of structural factors on personality development, and on ways in which individual internal states and behavioral patterns affect functioning of social systems.

**602-603 Seminars in Social Theory.** Seminars analyze in depth major social theorists or major lines of theoretical development. Specific theory to be covered in any semester announced in advance.

**632 Seminar: Contemporary Research in Demography.** Critical analysis of recent research investigations in demography.

**641 Seminar: Methods of Research.** Exemplary empirical researches in sociology and social psychology examined to reveal their technical machinery and their implicit explanatory models and theoretical positions.

**643 Seminar: Sociology of Medicine.** Selected topics in medical sociological research.

**644 Seminar: Political Sociology.** Relationship between social groups and political institutions. Macro, structural, comparative issues. Structure of above relationship and structural constraints upon it at societal level analyzed. Major comparative focus one vs. two vs. multiparty systems.

**647 Seminar: Inequality in America.** Recent trends in distribution of income, occupational rank, educational attainment in U.S. and attempts to modify them through government policy.

**648 Seminar: The U.S. Presence in Latin America (Economics 648).** Examination of U.S. Government, corporate, cultural activities in selected Latin American countries.

**653 Seminar: Sociology of Religion.** Selected topics in religion in Western society.

**657 Seminar: Social Change and the Community.** Structural and social psychological aspects of changing community.

**659 Seminar: Sociology of Adulthood and Aging.** Focus is on latter half of life cycle and utilizes both institutional and social psychological frameworks. Theory and research related to following topics discussed: middle aged and elderly in relation to family, economy, polity; demographic trends and issues; social aspects of health; adult socialization; role changes and role crises. Emphasis depends upon background and interests of students.

**662-663 Seminar: Social Systems Analysis.** Foundations of social systems analysis.

**670 Seminar: Economic Demography and Development (Economics 670).** Economic aspects of population dynamics with emphasis on interaction between population change and economic development. Topics: role of economic factors in fertility, mortality, migration; place of population growth and migration in development and modernization process; policy implications of rapid vs. slow or zero population growth for economic development.

**671 Seminar: Urbanization.** Analysis of theories of urbanization and related aspects of social change. Comparative studies of urbanization evaluated in theoretical and methodological terms in order to make an evaluation of current state of information in this subject area.

**681-682 Seminar in Social Psychology.** Research-oriented analysis of selected topics in social psychology.

**683 Research Practicum in Social Psychology.** Research on social interaction. The organization of interactive behavior viewed sequentially. Several models of such behavior investigated through a series of observations and experiments.

**684 Seminar: Feminine Identity.** Examination, within context of self-identity theory, of phenomena relating to formation for feminine identity. Topics: self-esteem, self preservation, social interaction, deviance.

**685 Seminar: Social Change and Modernization.** Neoevolutionary social structure and personality theories of social change. Analysis on relating theory to empirical research on industrialization and modernization in developing societies.

**691-692 Directed Research.**

## 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 711 Seminar in Statistical Methods.**

**Industrial and Labor Relations 712 Theory of Sampling.**

**Mathematics 371 Basic Probability.**

**Mathematics 472 Statistics.**

**Mathematics 473 Statistics.**

**Mathematics 475 Statistics.**

**Mathematics 571 Probability Theory.**

**Mathematics 572 Probability Theory.**

**Mathematics 573 Experimental Design, Multivariate Analysis.**

**Mathematics 574 Probability and Statistics.**

**Mathematics 575 Sequential Analysis, Multiple Decision Problems.**

**Mathematics 577 Nonparametric Inference, Asymptotic Theory.**

**Mathematics 579 Information Theory.**

**Mathematics 674 Experimental Design, Multivariate Analysis.**

**Mathematics 675-676 Statistical Decision Theory.**

**Mathematics 677-678 Stochastic Processes.**

**Operations Research IOD660 (9460) Introduction to Probability Theory with Engineering Applications.**

**Operations Research IOE670 (9470) Introduction to Statistical Theory with Engineering Applications.**

**Operations Research IOE512 (9512) Statistical Methods in Quality and Reliability Control.**

**Operations Research IOE622 (9522) Operations Research I.**

**Operations Research IOE627 (9527) Theory of Traffic Flow.**

**Operations Research IOE660 (9560) Applied Stochastic Processes.**

**Operations Research IOE662 (9562) Inventory Theory.**

**Operations Research IOE670 (9570) Intermediate Statistics.**

**Operations Research IOE671 (9571) Design of Experiments.**

**Operations Research IOE672 (9572) Statistical Decision Theory.**

**Operations Research IOE761 (9561) Queuing Theory.**

**Operations Research IOE765 (9565) Time-Series Analysis.**

**Operations Research IOE773 (9573) Statistical Multiple-Decision Procedures.**

**Operations Research IOE774 (9574) Nonparametric Statistical Analysis.**

**Plant Breeding and Biometry 408 Probability and Statistics I.**

**Plant Breeding and Biometry 409 Probability and Statistics II.**

**Plant Breeding and Biometry 411 Stochastic Models in Biology.**

**Plant Breeding and Biometry 412 Deterministic 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 520 Design of Experiments III.**

## Theatre Arts

### Acting

**380-381 Acting.** Practical emphasis on integration of conception, preparation of role, techniques of presentation.

**580 Graduate Acting.** Study and practice of fundamental and advanced techniques and methodology.

**585 Kineshetics 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, physiotherapy as applied to performing arts.

**586 Kinesthetics for the Theatre.** Continuation of 585 with introduction to technique of weaponry, combat, stage dueling.

**575-576 First Year American Mime.** The actor is taught to create and perform symbolic activities in mime form. First year's work divided into acting, movement, material.

**577-578 Second Year American Mime.** Continuation of 575-576 with emphasis on directing, design, creative imagination. Work completed by creating and playing of scenes.

## Voice and Speech

**382 Voice and Speech for Performance.** Study of voice and speech variables and their nature when applied to theatrical performance. Emphasis on ear training and techniques of voice production to achieve precision of articulation, and to improve vocal range, resonance, flexibility. Laboratory sessions under supervision of instructor include programmed self-instruction in General American and English phonetics, work on individual voice and articulation problems.

**383 Voice and Speech for Performance.** Advanced voice and diction for the stage. Stage dialects studied through combined approach of applied phonetics and ear training. Continued work in techniques of voice production to improve range, resonance, flexibility.

**582-583 Graduate Voice and Speech for Performance.** Emphasis on vocal interpretation of roles. Application of special skills and vocal technique in building character.

## Dance

**301 Dance Technique.** Modern and ballet technique.

**310 Advanced Dance Composition.** Problems in composition for groups, and music resources for dancers.

**311 Advanced Dance Composition.** Further problems in composition for groups.

**314-315 History of Dance.** Survey of history of dance from ancient to contemporary times with emphasis on development of theatrical forms in Western civilization.

**318 Period Dance.** Sampling of social dances from Renaissance to present with emphasis on pinpointing basic differences in movement styles and customs in various periods.

**410 Individual Problems in Composition.** Individual problems in composition.

**418 Seminar in History of Dance.** See instructor for description of particular aspect of history of dance to be investigated.

## Directing

**398 First Principles of Directing.** Study and

practice of fundamental craft of director. Structure of visual and temporary patterns as interpretation of script; rehearsal procedures and techniques; relationship of technical and design arts to directorial approach. Lecture, discussion, demonstration, practice. Students prepare scenes for class critique, demonstration, revision.

**498 Advanced Directing.** Investigation of theatrical meaning of a play and methods by which such meaning may be communicated in modern theatre. Discussion and studio practice.

**499 Projects in Directing.** Planning and execution of directing projects by advanced students in public facilities of Theatre Arts Department.

## Theatre Production and Design

**350-351 Theatre Practice.** Work on specific projects and/or productions under supervision of set designer, costume designer, or technical director.

**354 Stagecraft.** 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, technical drawing. Practice in scene and costume construction, painting, lighting in both laboratory and actual productions.

**362 Stage Lighting.** Introduction to lighting design for the theatre, beginning with basic foundation in types and functions of different lighting instruments, control equipment, light sources, color, reflection and refraction problems. Acquaints the student with principal approaches to lighting for a production, including various design concepts and elements to be considered by lighting designer.

**364-365 Stage Design I and II.** Stage scenery design from specifics of mass, space, color to completed theatrical design. Laboratory work with designer in rendering, scene painting, basic drafting, decor, lighting.

**366-367 Costume Design I and II.** Stage costume design and construction. Practice in costume design, period research, rendering techniques.

**466 Advanced Costume Design.** Projects in stage costume design and rendering techniques. Emphasis on design of total production.

**467 Advanced Costume Construction.** Projects in application of historical patterning for the stage.

## Playwriting

**348 Playwriting.** Laboratory for discussion of student plays. Each student expected to write two or three one-act plays, or one full-length play.

**349 Advanced Playwriting.** Continuation of 348.

## Theatre History, Literature, and Theory

**300 Independent Study.** Individual study of special topics.

**325 Classic and Renaissance Drama.** Readings in world drama from Greeks to Shakespeare, including dramatists: Aeschylus, Sophocles, Aristophanes, Plautus, Kalidasa, Zemi, Machiavelli, Lope de Vega, Calderon, Marlowe.

**326 European Drama 1660-1900.** Readings from major dramatists from Molière to Ibsen, including authors: Racine, Congreve, Sheridan, Schiller, Goethe, Hugo, Büchner, Gogol, Turgenev, Zola, Hauptmann, Chekov.

**327 Modern Drama.** Readings from major dramatists of twentieth century, including authors: Shaw, Pirandello, Brecht, O'Casey, O'Neill, Williams, Miller, Lorca, Beckett, Ionesco, Genet, Pinter, Duerrenmatt, Albee.

**333 History of the Theatre I.** Survey of characteristics of primitive theatre and of theatrical styles and production modes in Classical Greece, Rome, Medieval Europe, India, China and Japan, Renaissance England, Spain.

**334 History of the Theatre II.** Survey of theatrical styles and production modes since 1642. Among areas considered: Renaissance France; English Restoration; eighteenth and nineteenth centuries in England, France, Germany; modern international stage.

**335 American Drama and Theatre.** Study of American theatre and representative American plays with emphasis on drama from O'Neill to present.

**336 Theory of the Theatre and Drama.** Survey of dramatic and theatrical theories with emphasis on Aristotelian tradition of dramatic criticism and on theatrical theories and practices of Stanislavski, Brecht, Grotowski.

**435 The Roots of Modernism.** Plays and stagings of late nineteenth-century and early twentieth-century theatre which typify major artistic movements and intellectual currents of "Modernism," especially Realism, Naturalism, Symbolism, Expressionism, early Surrealism.

**442 Ibsen-Strindberg.** Study of major dramas of Ibsen and Strindberg in historical perspective and as illustrations of development of each author's dramatic technique.

**530 Literature and the Theatre.** Analysis of various types of dramatic literature from point of view of theatrical medium.

**532 Theatre Aesthetics.** Chief theories of dramatic production in relation to aesthetic principles.

**632 Seminar In Theatre Aesthetics.**

**633 Seminar In Theatre History.**

**636 Seminar In Dramatic Criticism.**

**637 Seminar In Dramatic Theory.** See instructor for description of particular aspect of dramatic theory to be investigated.

**638 Seminar In Theory of the Theatre.** See instructor for description of particular aspect of theory of theatre to be investigated.

**699 Seminar In Theories of Directing.**

**700 Introduction to Research and Bibliography in Theatre Arts.**

**990 Theses and Special Problems In Drama and the Theatre.**

## Cinema

### 375 History and Theory of the Cinema I.

Description, interpretation, evaluation of films as works of art and as objects for mass consumption considered within context of history of feature films. Statements concerning nature and functions of film discussed in relationship to films screened; contemporary methods of analysis, such as auteur theory, genre theory, semiology introduced. Lectures, screenings, discussion.

### 376 History and Theory of the Cinema II.

Introduction to history and theory of documentary and experimental films. Major documentary figures covered include Vertov, Flaherty, Grierson, Ivens, Lorentz, Riefenstahl, Capra, the cinema-verite filmmakers. Within history of experimental films emphasis on avant-garde of Twenties, surrealists' reaction to avant-garde, movement toward documentary in Thirties, American experimental films from Forties to present. Lectures, screenings, and discussion.

**377 Fundamentals of Cinematography.** Mechanics and expressive potentials of 16mm filmmaking, including nonsynchronous sound. Each student makes two short films.

**675 Seminar In the Cinema.** Intensive study of selected topics in film theory.

## Theoretical and Applied Mechanics

### Engineering Mathematics

**IAA770-771 (1170-71) Foundations of Applied Mathematics.** Differs substantially in content and emphasis from methods-oriented courses such as IAA680-684 (1180-84), Math 415-16, Math 421-23. Various applied mathematical topics from viewpoint of underlying abstract mathematical similarity; introductory treatment of unifying principles from modern analysis and algebra. Subject matter: sets, logic, switching circuits; algebraic systems and isomorphism; completion-embedding principle, from natural numbers to distribution theory, including real-complex embedding, Riemann-Lebesgue integral embedding, function-distribution embedding; contraction mapping principle, iterative solution techniques, existence-uniqueness theorems, Cartesian arithmetization of Euclidean geometry and its extension to Hilbert spaces; projection principle

and approximation theory; symmetric linear operators, matrix diagonalization, boundary value problems; local approximation of nonlinear functions by linear functions, differentials, variational calculus, gradient methods, generalized Newton-Raphson process and boundary value problems. Physical motivation drawn from a variety of sources, historical and current, including literature of theoretical mechanics, communication and control theory, numerical analysis.

**IAA680 (1180) Methods of Applied Mathematics I.**

For students who plan to use applied mathematics frequently. Ordinary differential equations; series; orthogonal functions and Sturm-Liouville theory; functions of several real variables; vector fields and integral theorems; matrices; partial differential equations. Emphasis on applications and techniques of solutions, wherever possible. At the level of *Mathematics of Physics and Modern Engineering* by Sokolnikoff and Redheffer.

**IAA681 (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.

**IAA682 (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 and boundary layers. Development in terms of problems drawn from vibrations and acoustics, fluid mechanics and elasticity, heat transfer, electromagnetics.

**IAA683 (1183) Methods of Applied**

**Mathematics IV.** More extensive treatment of 1182 in same spirit. Topics: method of matched asymptotic expansions; two timing; 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.

**IAA684 (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**

**IAB663 (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 mechanics of elastic deformable bodies with structural applications.

**IAB664 (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.

**IAB765 (1265) Mathematical Theory of Elasticity.**

Development in tensor form of 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; Cauchy integral techniques in elasticity, torsion problems.

**IAB667 (1267) Introduction to the Inelastic**

**Behavior of Solids and Structures.** Introduction to

physical aspects of inelastic material behavior. Idealized models for microscopic analysis of elastic, plastic, viscous, viscoplastic, locking materials. Mathematical formulations and methods of solution. Design concepts.

**IAB668 (1268) Theory of Plasticity.** Theory of

inelastic behavior of materials. Plastic stress-strain laws, yield criteria, 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, shells. Shakedown. Selected topics in dynamic plasticity.

**IAB771 (1271) Theory of Plates and Shells.**

Topics: review of classical plate theory; Reissner plate theory; theory of anisotropic plates with special emphasis on plates of composite materials and curvilinear coordinates on a surface; general shell theories including Love's first and second approximations and Flügge-Byrne and Naghdi-Reissner shell theories; membrane theory with applications to shells of revolution; Nemenyi-Truesdell stress function; bending theory solutions for cylindrical shells with and without transverse shear deformation.

**IAB680 (1280) Composite Materials (Materials Science and Engineering ITF725).**

Physical Basis of strength, elastic modulus, fracture resistance of composite materials; micro- and macro-mechanics of composites, their mechanical response, important composite systems including fabrication, processing, 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.

**IAB790 (1290) Continuum Mechanics and Thermodynamics.** Kinematics. Conservation laws. Entropy inequality. Constitutive equations. Frame indifference. Material symmetry. Simple materials and position of classical theories in framework of modern continuum mechanics.

**IAB791 (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.

**IAB792 (1292) Continuum Mechanics and Thermodynamics of Fluids.** Viscometric flows of non-Newtonian fluids. Theory of mixtures. Oriented media and theory of liquid crystals.

## Dynamics and Vibrations

**IAC662 (1362) Vibration of Elastic Systems.** Review of vibration 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.

**IAC766 (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.

**IAC670 (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.

**IAC771 (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.

**IAC675 (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.

**IAC676 (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.

**IAC781 (1381) Dynamics of Flight.** Introduction to dynamics of atmospheric vehicles. Static stability and control. Derivation of general equations of unsteady motion. Small disturbance equations. Dynamic stability. Dynamic response to controls. Stability augmentation and automatic control. Flight path optimization techniques. At level of Etkin, *Dynamics of Flight*.

## Experimental Mechanics

**IAD659 (1459) Experimental Mechanics.** Student selects four to six experiments to meet 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.

**IAD660 (1460) Experimental Mechanics.** Student chooses two to three in-depth experiments from areas very active in contemporary experimental mechanics and reflecting some research interests of faculty. Experiments utilizing holographic interferometry techniques and internal friction techniques now planned.

## Space Mechanics and Aerospace Structures

**IAG672 (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.

**IAG673 (1773) Mechanics of the Solar System.** Application of principles of mechanics to explain large-scale physical phenomena in solar system. An understanding of interplanetary environment developed. Topics: geophysical principles and ideas as applied to the Earth and other planets; seismic waves, free oscillations, free and forced rotation, gravitational potentials. Equilibrium tidal theory, tidal interactions, orbital evolution of the earth-moon system, spin-orbit coupling of Mercury and Venus. Dynamical characteristics of comets, asteroids, interplanetary dust. Relativistic perihelion precession of Mercury.

**IAG674 (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, interplanetary trajectories.

**IAH666 (1866) Pattern Classification.** Graph theoretic and criterion function clustering techniques. Clustering methods based on the theory of fuzzy sets. Linear and nonlinear categorizers. Error correcting procedures. Group averaging techniques and feature extraction. Applications to biological taxonomy, automated character recognition, medical diagnosis.

**IAH692 (1892) Current Research Problems in Bionics and Robots.** Graduate-level seminar, concentrating on a few topics in biomechanics, bioengineering, bionics, robots at some depth. Students give oral presentations on current research, and faculty and students 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

**IAJ704-705 (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.

**IAJ821-822 (1921, 1922) Project in Mechanics.** Minimum of three credit hours must be completed by each candidate for Master of Engineering (Engineering Mechanics) degree.

**IAJ896 (1996) Research in Theoretical and Applied Mechanics.** Thesis, literature survey, or independent research under guidance of staff member.

**IAJ897 (1997) Selected Topics in Theoretical and Applied Mechanics.** Special lectures or seminars on subjects of interest: topics to be announced.

### Urban Studies

Urban Studies courses are all listed under various colleges. A copy of the *Directory of Courses for Urban Studies* may be obtained from the Field representative, Professor B. G. Jones or from the Center for Urban Development Research at 726 University Avenue.

### Vegetable Crops

**401 Vegetable Crops Physiology.** Physiological bases of cultural practice and application of these principles to problems in vegetable production. Original literature used to illustrate principles involved. Experimental material studied in 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; environmental factors affecting growth.

### 413 Kinds and Varieties of Vegetables.

**429 Special Topics in Plant Science Extension.** 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 organizations. Topics related to extension in other countries as well as in U.S.

**501 Research Methods in Applied Plant Science.** Planning of research programs as influenced by various economic and geographic environments. Advantages and limitations of conventional experimental designs as they apply to specific research problems. Discussions include critical interpretation of experimental results from literature. Many topics directly applicable to 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 required to present oral reports on current literature and to prepare and present a research proposal.

## Veterinary Medicine

### Anatomy

**502 Developmental and Microscopic Anatomy.** Study of development designed to provide foundation for understanding of definitive anatomy and formation of anomalies. Latter part of course devoted to cytology and histology, illustrated with material from domestic animals.

**503 Microscopic Anatomy.** Microscopic structure of tissues and organs of domestic animals studied. Illustrated lectures relate structure to function, correlate microscopic and gross anatomy, establish a foundation for subsequent studies in physiology and pathology. Slides of tissues and organs provided.

**504 Neuroanatomy.** Structure and function of nervous system of domestic animals studied by functional systems. Clinical cases with pertinent lesions demonstrated with each system.

**601 Advanced Anatomy.** Advanced study under personal direction.

**700 Vertebrate Morphology.** Designed for graduate students in animal science, nutrition, conservation. Dissection of dog serves as basis for functional consideration of component parts of mammalian organ systems. Followed by discussion of fetal and adult cow, other species of interest.

**701 Comparative Anatomy of the Digestive System.** General knowledge of gross anatomy of each organ assumed. Emphasis on

micro-macroscopic muscular and vascular architecture, innervation, and functional cytology of epithelium.

## Avian Diseases

### 770 Advanced Work in Avian Diseases.

## Large Animal Medicine, Obstetrics, and Surgery

**571 Clinical Pathology.** Application of techniques of hematology, urinalysis, cytology, semen examinations, other laboratory procedures in diagnosis; biochemical changes in blood and other fluids in disease; study of pathological alterations in clinical cases.

**678 Veterinary Medicine RLA (Mechanical Engineering MB562 [3362]) Mechanics of Biological Materials and Systems.** Basic concepts in engineering mechanics (statics, dynamics, strength of materials). Mechanical properties of biological tissues (bone, soft tissue, muscle). Applications of engineering mechanics to specific biomechanical problems such as fractures, fixation of fractures, strength of suture closure of wounds, analysis of animal motion, mechanical aspects of lameness in horses, total joint replacement (internal prostheses). Intended for students in veterinary medicine and life sciences. Not open to engineering students.

**737 Advanced Work in Reproduction Pathology and Bacteriology, Medicine, Obstetrics, and Surgery.** Properly prepared students may undertake special problems or receive special assignments in field of reproductive pathology, microbiology, equine nutrition, medicine, obstetrics, surgery.

**740 Reproductive Pathology.** Advanced course in reproductive pathology of both male and female domestic animals with equal emphasis on gross and microscopic lesions of their genital tracts.

**776 Urogenital Surgery of the Horse.** Surgical diseases of urogenital system of mare and stallion. Lectures in seminar-discussion form. Anatomy laboratory utilizes the prosected specimens and video-tape, in collaboration with Anatomy Department. Surgical pathology laboratories also utilize cadaver dissections.

**777 Surgery of the Digestive System of the Horse.** Surgical diseases of digestive system including oral cavity, pharynx and esophagus, gastrointestinal tract. Special consideration of problems arising from diseased teeth and obstructive disease of esophagus and intestine. Laparotomy techniques covered in depth. Lectures in seminar-discussion form. Laboratories employ dissected specimens. Presented in collaboration with Anatomy Department and Pathology Department.

**778 Gastroenterology Conference.** Demonstration and discussion of cases in Large and Small Animal Clinics.

**779 Veterinary Gastroenterology.** Deals with pathogenesis diagnosis and treatment of major medical diseases of gastrointestinal tract of domestic animals.

**780 Veterinary Research Methods.** Combined lecture, laboratory, seminar in experimental design, statistical analysis, statistical inferences. Summarization and publication of research data discussed.

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

**315 Basic Immunology Lectures.** Elementary level coverage of spectrum of facts and concepts in current immunology, special emphasis on biologic function of immune response in protective immunity.

**316 Pathogenic Microbiology.** Includes microbiology, virology, serology.

**519 Epidemiology and Infectious Diseases.** Survey of application of epidemiologic methodology to investigation of animal and human disease outbreaks, investigation of cause of new or unknown diseases, development and evaluation of eradication and control programs. Diagnosis, clinical signs, prevention, control of animal diseases exotic to the United States and of infectious diseases transmissible between animals and man described from an etiologic and epidemiologic viewpoint, with sections on food, waterborne, occupational diseases.

**520 Applied Microbiology and Preventive Medicine.** Continuation of course 519. Application of fundamental concepts of microbiology and immunology to animal disease diagnosis, surveillance and control including development, evaluation and use of biologics. Emphasis on influence exerted by veterinarians in preventing diseases transmissible by agricultural products. Relationship of practicing veterinarian to disease control agencies and responsibility of individual veterinarians in maintenance of human health and environmental quality.

**606 Small Animal Infectious Diseases.** Elective course. Gives the future small animal practitioner greater understanding of infectious diseases of dogs and cats. It emphasizes etiology, pathogenesis, and prevention, including maternal immunity, vaccination, and hospital design as it relates to spread of diseases. Diseases covered include diseases of dogs and cats that are caused by viruses, bacteria, fungi, protozoa.

**705 Advanced Immunology Lectures.** Lectures cover field of immunology at an advanced level. Lecture topics: phylogeny and ontogeny, antigens, immunoglobulins, antibody synthesis, hypersensitivity, antigen-antibody reactions, and protective immunity.

Detailed course outlines available from course secretary.

**706 Advanced Immunology Laboratory.** Three major parts: (1) comprehensive exercise in antibody production and analysis, (2) series of individual exercises in modern immunological techniques, (3) demonstrations of immunological instrumentation and techniques. Detailed course outlines available from course secretary.

**707 Advanced Work in Bacteriology, Virology, or Immunology.** Properly prepared students may undertake special problems or receive special assignments.

**708 Advanced Animal Virology Lectures.** Principles of animal virology stressed. Lecture topics: structure and classification of animal viruses, multiplication of RNA and DNA viruses, pathogenesis, host-response to viral infections, biology of selected oncogenic viruses; chronic effects of viral persistence; evolutionary aspects; systematic treatment of selected viral groups. Course outline available from course secretary.

**709 Advanced Animal Virology Laboratory.** Discussions and laboratory exercises covering preparation of cell cultures, concentration and purification of virions, analysis of viral proteins and nucleic acids, virus assays and serology, cell transformation.

**710 Microbiology Seminar.**

**711 Laboratory Methods of Diagnosis.** Instruction and practice in application of bacteriological and serological methods for diagnosis of disease.

**712 Immunopathology and Clinical Immunology.** Presents current immunologic techniques and immunopathological concepts applicable to diagnosis of specific diseases of domestic animals. Special emphasis on immunologically mediated disorders. Taught on a systems basis. Term project and report required.

## Pathology

**535 General Pathology.** Study of disease processes, including congenital anomalies, circulatory diseases, degenerations, necrosis, inflammation, neoplastic diseases (tumors). Gross and microscopic features discussed in relation to effects on host animal.

**536 Special Pathology.** Systematic study of diseases in each organ system, with emphasis on differential diagnostic features. Veterinary pathologists, specialists in several aspects of the course, participate in teaching areas of their specialization.

**537 Basic Parasitology.** Systematic study of helminth and arthropod parasites of domestic animals with particular emphasis on identification and bionomics of forms of veterinary importance. Combined with Applied Parasitology.

**538 Applied Parasitology.** Organized study of parasitisms of domestic animals with particular

emphasis on features of diagnostic importance. Special attention given to laboratory and postmortem techniques of value in applied parasitology. Combined with Basic Parasitology.

**539 Introduction to Laboratory Animal Medicine.** Introduction to management and disease control in common laboratory animal species used in biological research including mice, rats, guinea pigs, hamsters, rabbits, poultry, nonhuman primates. Disease control in experimental colonies of dogs and cats discussed. Survey of preventive medicine and common diseases.

**571 Clinical Pathology.** See listing under Large Animal Medicine, Obstetrics, and Surgery.

**635 Special Problems in Pathology.** By permission of instructor only.

**636 Wildlife Pathology.** Presentation of nature and causes of diseases of wild rabbits, opossums, squirrels, deer, certain water fowl, some other species. Emphasis on epizootiology, etiology, pathogenesis, diagnostic lesions, effects on populations. Laboratory experience in specimen collection and necropsy techniques. Guest lectures by members of Department of Natural Resources on ecology and population dynamics.

**637 Postmortem Pathology.** Presentation of gross and microscopic lesions of diagnostic significance, employing color projection slides as illustrations. Emphasis on pathological and differential diagnosis of a wide spectrum of viral, metabolic, bacterial, parasitic, and other diseases.

**638 Fish Pathology.** Gross and microscopic pathology of spontaneous and some experimental diseases of fish. Normal anatomy and histology reviewed as introduction. Ecology of fish discussed as it relates to diseases. Lectures, color projection slides, fresh specimens, histologic slides used to illustrate and describe fish pathology.

**735 Pathology Seminar.** Required of all graduate students in pathology.

**736 Pathology of Nutritional Diseases.** Designed primarily for graduate students of nutrition.

**737 Advanced Work in Animal Parasitology.** Special problems concerned with parasites of domestic animals.

**738 Laboratory Methods of Diagnosis.** Instructions and practice in application of pathological methods for diagnosis of disease.

**739 Advanced Work in Pathology.** Properly prepared students may undertake special problems or receive special assignments.

**740 Reproductive Pathology.** See listing under Large Animal Medicine, Obstetrics, and Surgery.

**741 Advanced Work in Laboratory Animal Medicine.** Preventive medicine and diagnosis and pathology of spontaneous diseases of laboratory animals. Discussions and exercises in use of gnotobiotic and specific-pathogen-free animals for research purposes. Visits made to acquaint students

with design of various types of experimental animal facilities. By permission of instructor. Course starts in 1975.

**742 Ultrastructural Pathology.** Study directed toward development of capability in interpretation of electron micrographs of biological structures in health and disease. Techniques of electron microscopy of biological material briefly reviewed. Major part of course directed toward alterations of specific organelles and subcellular systems in pathologic processes, such as inflammation, neoplasia, the ultrastructural pathology of selected organ systems, e.g., kidney, blood vasculature, and liver.

**743 Gastroenteric Pathology.** Demonstration and discussion of necropsies.

## Physical Biology

**750 Radioisotopes In Biological Research—Principles and Practice.** Lectures, demonstrations, laboratory on fundamentals of atomic energy procedures and applications to biological research.

**751 Biological Effects of Radiation.** Lectures and demonstrations on radiation physics, radiation chemistry, radiation effects at cellular level, radiation effects in multicellular organisms, genetic effects of radiation, radioprotective and radiomimetic substances.

**752 Biological Membranes and Nutrient Transfer.** Introduction to elementary biophysical properties of biological membranes, theoretical aspects of permeability and transport, mechanism of transfer of inorganic and organic substances across intestine, placenta, kidney, erythrocytes, bacteria, other biological systems.

**753 Functional Organization of the Mammalian Nervous System.** Cellular, sensory, central integrative, motor aspects of nervous system considered with emphasis on electrophysiological approach. Laboratory studies include electrical activity of cells, reflexes, decerebrate rigidity, acoustic microphonic response, subcortical stimulation, evoked and spontaneous cortical activity.

**754 Special Topics In Mineralized Tissue.** Introduction to histology, anatomy, 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, calcium homeostatic mechanisms.

**755 Physical Biology Graduate Seminar.**

**756 Special Topics In Physical and Radiation Biology.**

**757 Experimental Physiology for Graduate Students.**

See also Physiology.

## Physiology, Biochemistry, and Pharmacology

**526 Physiology.** Physiology of cells, muscle, nerve, nervous system, respiration, urine secretion, temperature regulation.

**527 Physiology.** Physiology of blood, lymph, circulation, digestive system, endocrine organs, reproduction.

**625 Vertebrate Biochemistry Lectures.** Biochemical course emphasizing structure, function relationship, metabolic control in vertebrate systems.

**720 Special Problems In Physiology.** Laboratory work, conferences, collateral reading, and reports, adapted to needs of students.

**722 Methods In Gastroenterological Research.** Provides experience with variety of current physiological techniques for study of functions of gastrointestinal tract with special emphasis on their limitations.

**723 Comparative Gastroenterology.** Lectures emphasize: (1) functional comparison of invertebrate and vertebrate digestive systems, (2) preparations and procedures used to study function or malfunction in this system, (3) digestive tract diseases.

**724 Physiological Disposition of Drugs and Poisons.** Factors governing physiological disposition of drugs emphasized together with consideration of action of drugs affecting nervous system. General principles of chemotherapy and of toxicology also covered.

**726 Physiology.** Lectures and demonstrations on cellular physiology, muscle, nervous system, respiratory system, urine secretion, blood, lymph.

**727 Physiology.** Lectures and demonstrations on circulation, digestion, endocrine organs, metabolism, reproduction.

## 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. Advanced work 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*.

### List of Announcements

Following is a list of *Announcements* published by Cornell University to provide information on programs, faculty, facilities, curricula, and courses of the various academic units.

Agriculture and Life Sciences at Cornell  
New York State College of Agriculture and  
Life Sciences: Courses  
College of Architecture, Art, and Planning  
College of Arts and Sciences  
Department of Asian Studies  
Graduate School of Business and Public  
Administration  
Field of Education (Graduate)  
College of Engineering  
Engineering at Cornell  
Graduate Study in Engineering and Applied  
Sciences  
General Information\*  
Graduate School  
Graduate School: Course Descriptions  
School of Hotel Administration  
New York State College of Human Ecology  
New York State School of Industrial and Labor  
Relations  
Law School  
Medical College (New York City)  
Graduate School of Medical Sciences  
(New York City)  
Cornell University—New York Hospital  
School of Nursing (New York City)  
Graduate School of Nutrition  
Officer Education (ROTC)  
Summer Session  
New York State Veterinary College

\*The *Announcement of General Information* is designed to give prospective students pertinent information about all aspects and academic units of the University.

Requests for the publications listed above should be addressed to

Cornell University Announcements  
Edmund Ezra Day Hall  
Ithaca, New York 14850.

(The writer should include his zip code.)