880. Atomic and Molecular Structure
Fall. 3(3-0) 462 or approval of department.
Basic concepts of non-relativistic quantum mechanics will be developed and employed in a description of atomic and molecular structure.

881. Thermodynamics
Winter. 3(3-0) Approval of department.
Laws of thermodynamics and their application to pure substances and solutions.

882. Chemical Kinetics
Spring. 3(3-0) 880.
Rates and mechanisms of chemical reactions, reaction rate theory, kinetic theory of gases, photochemistry.

883. Rates and mechanisms of chemical reactions, reaction rate theory, kinetic theory of gases, photochemistry.

889. Problems and Reports
Fall, Winter, Spring, Summer. Variable credit. May re-enroll for a maximum of 15 credits. Approval of department.

890. Research
Fall, Winter, Spring, Summer. Variable credit. May re-enroll for a maximum of 15 credits. Approval of department.
Research in inorganic, analytical, organic, and physical chemistry.

900. Seminar
Summer. 2 credits. Approval of department.
Topics are selected from current active research areas.

913. Selected Topics in Inorganic Chemistry
Fall, Spring. 3(3-0) May re-enroll for a maximum of 9 credits if different topic is taken.
Rare earth elements, recent advances in the chemistry of metals or nonmetals, high-temperature chemistry. Coordination chemistry and non-aqueous solvents.

918. Seminar in Inorganic Chemistry
Fall, Winter, Spring. 0 or 1(1-0)
Discussions of recent advances and reports by graduate students on research problems.

924. Selected Topics in Analytical Chemistry
Fall, Spring. 2(2-0) May re-enroll for a maximum of 6 credits if different topic is taken.
Among topics which may be discussed are: advances in electro-analytical chemistry or spectroscopy; non-aqueous solvents in analytical chemistry; theory of acid-base and complexation equilibria.

938. Seminar in Analytical Chemistry
Fall, Winter, Spring. 0 or 1(1-0)
Discussions of recent advances and reports by graduate students on research problems.

955. Seminar in Organic Chemistry
Fall, Winter, Spring. 0 or 1(1-0)
Discussions of recent advances and reports by graduate students on research problems.

956. Seminar in Physical Chemistry
Fall. 3(3-0) May re-enroll for a maximum of 8 credits if different topic is taken. Approval of department.
Topics may be chosen from analysis and interpretation of the spectra of molecules, advanced molecular structure, magnetic resonance, spectroscopy, X-rays and crystal structure, statistical mechanics.

998. Seminar in Physical Chemistry
Fall, Winter, Spring. 0 or 1(1-0)
Discussions of recent advances and reports by graduate students on research problems.

999. Research
Fall, Winter, Spring, Summer. Variable credit. Approval of department.
Research in analytical, inorganic, organic, and physical chemistry.

CHEMISTRY

See Linguistics and Oriental and African Languages

CIVIL AND SANITARY ENGINEERING

College of Engineering

Civil Engineering

251. Elementary Surveying
Fall, Spring. 3(3-2) Trigonometry, EGR 160 or 267. Not open to majors.
Use of the tape, compass, level, and transit with simple maps; traverse closure and area computations. PROFILE, cross section and stadia surveys, U. S. land system.

252. Surveying I
Fall, Spring. 5(4-3) Trigonometry. Instruments, theory of measurements, error analysis, stadia, horizontal and vertical curves, U.S. Public Land System, observation for meridian.

280. Introduction to Environmental Engineering
(382.) Winter, Spring. 4(4-0) CEM 141 or 131, MTH 112.
Hydrology; ground water and surface water supply systems; wastewater treatment, methods of pollution control for solid waste, air, and noise.

305. Structural Mechanics I
Winter, Spring. 4(4-0) MMM 211.
Stability and determinacy of structures. Two and three dimensional determinate structures. Indeterminate structural analysis by displacement and force methods based upon equilibrium, compatibility and load-deformation relations.

308. Engineering Materials I
Winter, Spring. 4(3-3) MMM 211 or concurrently.
Structure, composition, physical, mechanical and rheological properties of non-metallic construction materials. Emphasis on aggregates, asphalt, inorganic cements, concrete, and wood.

311. Urban Utilities
Winter. 3(3-0)
Capacities, limitations and cost of public and semi-public utilities as they relate to the planning and design of the urban environment. Topics include transportation, water supply, storm drainage, sewage collection and treatment, solid waste and municipal finance.

312. Soil Mechanics I
Spring, Summer. 4(3-3) MMM 211.
Engineering properties of soils and their measurement. Effective stress concept, permeability, fluid flow in soils, stress-strain behavior, soil strength, compaction and consolidation of soils; field exploration and design problems.

321. Introductory Fluid Mechanics
Fall, Winter. 5(4-2) MMM 306.
Fluid properties; hydrostatics; control volume approach to conservation of mass, momentum and energy; dimensional analysis and dynamic similarity; fluid resistance; pipe and open channel flows; boundary layer concepts.

342. Survey of Transportation Systems
Fall. 4(4-0) Juniors; not open to majors.
Survey of engineering aspects of all forms of transportation with emphasis on highway transportation including highway systems, planning, economic and financial aspects, geometries and traffic studies.

346. Transportation
(446.) Fall. 3(3-0) MTH 214
Planning, design and evaluation of transportation systems. Operation and characteristics of transportation models, traffic flow and techniques for system selection.

347. Transportation Facilities
(447.) Winter. 4(3-3) 251 or 252.
Geometric design of highway and airport facilities; these considerations affect capacity, traffic control and economics of transport systems. Financing and administration of transport systems.
353. Surveying
Introduction to technique and decision making in surveying and photogrammetry.

370. Cost and Optimization
Engineering
Formulation of engineering decisions governed by current and future costs and returns. Comparison and optimization of alternative engineering projects, products, and processes.

372. Construction Estimating
Cost studies of construction activities with emphasis on labor productivity and operating characteristics of equipment under various site conditions. Interpretation of drawings and specifications.

374. Legal Aspects of Engineering
The professional engineer's relationship with the legal aspects of engineering. Special emphasis on contract documents.

380. Civil Engineering Analysis
Analysis of civil engineering problems by numerical and statistical methods. Approximate methods and error analysis. Application to computer use.

400. Structural Mechanics II
Energy methods in static and dynamic structural analysis, including the principles of virtual displacements and virtual forces. Influence lines. Matrix analysis of structures. Introduction to stiffness coefficients. Computer facilities are used.

405. Structural Design in Steel
Reinforced concrete beams, columns, slabs, footings and retaining walls. Elastic theory and ultimate strength concepts.

406. Structural Design in Concrete

410. Structural Mechanics III
Introduction to inelastic behavior of structures.

419. Soil Mechanics II
Foundation engineering. Immediate, consolidation, and secondary settlements; stress distributions in soil masses; lateral earth pressures on structures; bearing capacity of shallow foundations; introduction to stability analysis of earth structures.

421. Hydrology
Engineering hydrology; frequency and precipitation analysis; streamflow analysis and the unit hydrograph; flood prediction; rainfall-runoff correlations; urban hydrology.

422. Hydraulic Systems
Steady flow in pipe networks; open channel flow; turbomachinery; groundwater hydraulics; introduction to unsteady flows. Applications to water supply systems; aquifer analysis; seepage and water hammer.

445. Transportation Planning
Urban transportation facilities; design of transportation models for urban highways and public transit. Trip generation, trip distribution, mode split and traffic assignment. Transport agencies function and services.

449. Highway Engineering
Design concepts of roadways, facilities, drainage and pavement design. Maintenance, construction and supervision methods and procedures.

471. Scheduling Construction Activities
Techniques for coordinating and controlling construction projects. Scheduling under the constraints of deadlines, uncertain time estimates and limited resources. Computer programs and data files for effective management.

481. Water and Wastewater Analysis
Quantitative analysis; bacteriological and chemical characteristics of water and wastewater; principles of softening, iron removal, coagulation and chlorination; laboratory examination of water and wastewater including turbidity, solids, chlorides, chlorine, etc.

483. Water and Wastewater Treatment
Water treatment theory, design and engineering. Water and wastewater treatment theory and design, including the principles of sedimentation, coagulation, softening, iron removal, and chlorination; wastewater treatment plants; wastewater treatment theory and design including grit chambers, activated sludge, trickling filters, and anaerobic digesters.

499. Civil Engineering Projects
Original civil engineering problems of specific interest to the student and a faculty member. Student's proposal describing problem required prior to approval.

500. Operations Research Techniques for Civil Engineers
Elements of deterministic methods of operations research with emphasis on computational techniques and applications to civil engineering problems such as structural design, water supply, transportation, and construction management.

502. Structural Dynamics I
Basic concepts in structural dynamics; dynamic loading on structures due to blasts and earthquakes; dynamic properties of structures; methods of analysis; design approach to blast and earthquake-resistant structures; dynamic behavior of bridges and other topics.

804. Advanced Structural Theory I

805. Advanced Theory of Reinforced Concrete I
Deflection, torsion, shrinkage, plastic flow, and ultimate strength of concrete structures. Prestressed concrete.

807. Model Analysis
Basic theory of the analysis of structures by means of models. Laboratory work on models. Begg's deformeter and electric resistance type gauges for the measurement of static and dynamic strains.

815. Principles of Highway and Airport Soils
Foundation problems related to highways and airports, relation of subsoil conditions to design and construction, analytical review of laboratory and field results.

817. Mechanical Properties of Soils
Mechanical properties of soil including stress-strain behavior; conditions of failure and shear strengths; consolidation theory and permeability. Laboratory determination of soil properties including interpretation of experimental data for use in practice.

818. Advanced Soil Mechanics
Foundations and earth retaining structures; bearing capacity, lateral resistance and settlement of deep foundations; earth pressures on braced excavations and sheet pile walls; design of caissons and cofferdams.

821. Flow of Fluids in Porous Media

825. Fluids
Application of hydromechanics to hydraulic engineering: open channel flow, uniform flow and gradually varied flow, flow routing, supercritical flow in steep chutes, bends and transitions; hydraulic jump and structures for the dissipation of energy.
843. Traffic Engineering
Characteristics
Winter. 3(3-0) 346, STH 421.
Safety analyses, flow and capacity characteristics, statistical properties of traffic, queuing characteristics at intersections, delay characteristics and analyses.

844. Traffic Engineering Theory and Control
Spring. 3(3-0) 843.
Application of the theory of traffic flow to the design and control of traffic systems. Dispatching, scheduling and network analysis. Applications to highways, airport operation and urban transportation models.

846. Highway Planning
Fall. 3(3-0) 346 or approval of department.
Highway inventory, road use studies and programming, analysis of highway costs, economic considerations in location and design.

847. Geometric Design of Highways
Winter. 3(3-0) 346 or approval of department.
Design of streets and highways including intersections, parking facilities, capacity, channelization and roadway appurtenances.

848. Transportation Models
Spring. 3(3-0) 448.
Analysis of transportation modeling process, including error propagation and parameter sensitivity analysis. Comparative attributes of zonal size and model sequence decisions on the evaluation of system alternatives.

880. Special Problems in Civil Engineering
Fall, Winter, Spring, Summer. Variable credit. Approval of department.
Research problems of limited scope not pertaining to thesis accomplished under 899 or 999.

899. Research
(EGR 899.) Fall, Winter, Spring, Summer. Variable credit. Approval of department.

904. Advanced Structural Theory II
Spring. 4(4-0) 804 or approval of department.
Energy (variational) approach to formulation and solution of problems in structural mechanics: stresses, displacements and stability of continuum and structural elements. Approximation methods including Rayleigh-Ritz and finite element.

905. Advanced Theory and Design of Reinforced Concrete II
Spring. 3(3-0) 805.
Continuation of 805 with application of theory to analysis and design of tanks, rigid frames, and shells.

906. Advanced Structural Steel Design
Spring. 3(3-0) 406.
Analysis and design of multiple-story building frames, continuous trusses and rigid-frame girder bridges in structural steel. Plastic design.

908. Numerical Methods in Structural Engineering
Winter. 3(3-2) Approval of department.
Solution of mathematical equations by means of successive numerical approximations and the application of these numerical methods to structural problems.

909. Elastic Thin Shells
Spring. 4(4-0) 804 or MMM 815 or approval of department; MTH 421. Interdepartmental with the Metallurgy, Mechanics and Materials Science Department.
Elements of differential geometry, membrane theory of shells, Poisson's strain function, deformation and bending of shells of revolution and shallow shells.

912. Theory of Plates
Winter. 4(4-0) 804 or MMM 815 or approval of department; MTH 422. Interdepartmental with and administered by the Metallurgy, Mechanics and Materials Science Department.
Bending of thin elastic plates with various shapes and boundary conditions; application of energy principles and approximate methods of solution; thick plates; large deflection theory; sandwich plates.

915. Earth Structures
Spring. 3(3-0) 817 or approval of department.
Embankments, earth dams, natural and cut slopes, stability of circular and composite slip surfaces; performance of embankments on soft foundations; seepage through earth dams; instrumentation for field performance evaluation.

916. Soil Dynamics
Winter. 3(3-0) 817 or approval of department.
Characteristics of ground motions during earthquakes; dynamic soil properties; liquefaction and settlement under transient and repeated loadings; foundation design for vibratory loads; wave propagation in soil media.

999. Research
(EGR 999.) Fall, Winter, Spring, Summer. Variable credit. Approval of department.

Sanitary Engineering

803. Treatment of Industrial Wastes
Spring. 3(3-0) C E 483.
Physical, chemical and biological treatment methods for industrial wastes.

805. Water Treatment Principles
Winter. 3(3-0) C E 483.
Chemical and physical principles of water treatment.

808. Sewage Collection and Treatment
Spring. 3(3-0) C E 483.
Chemical, physical and biological principles of sewage collection and treatment.

899. Research
Fall, Winter, Spring, Summer. Variable credit. Approval of department.

905. Biological Principles of Sanitary Engineering I
Fall. 3(2-3) C E 483.
Fundamental physical, chemical, and biological principles relating to the field of sanitary engineering.

906. Biological Principles of Sanitary Engineering II
Winter. 3(2-3) 905.
Fundamental physical, chemical, and biological principles relating to the field of sanitary engineering.

999. Research
Fall, Winter, Spring, Summer. Variable credit. Approval of department.

CLASSICAL STUDIES
See Romance Languages

COMMUNICATION

College of Communication Arts

100. Human Communication I
Fall, Winter, Spring. 3(3-0)
Process and functions of communication. Principles underlying communication behavior. Practice in analyzing communication situations and in speaking and writing.

101. Human Communication II
Fall, Winter, Spring. 3(3-0)
Continuation of 100, with greater emphasis on speaking and writing, and on analyzing increasingly complex communication situations.

109. Methods of Inquiry
Fall, Winter, Spring, Summer. 3(3-0)
Majors and minors only. 101.
Major theoretics orientations toward communication. Primary tools of scholarly inquiry.

205. Persuasion
Fall, Winter, Spring. 4(4-0)
Process of influencing human behavior through persuasive communication. Experience in creating persuasive messages and in evaluating the acceptability of persuasive attempts.

210. Leadership
Fall, Winter. 4(4-0) 100.
Principles and practices in the utilization of communication for effective leadership.

299. Individual Projects
Fall, Winter, Spring. Variable credit. May re-enroll for a maximum of 15 credits. 199, approval of project proposal by department.
Indpendent research, experience in communication laboratories, or tutorial work in communication skills.

300. The Effects of Mass Communication II
Fall, Winter, Spring. 4(3-0)
Majors must enroll in 300R concurrently. Major social effects of mass media on audience behavior. Political communication. Media effects on children. Message strategies producing attitude change. Interrelationship between mass media and interpersonal communication. Decision making in mass media.

300R. Effects of Communication II
Fall, Winter, Spring. 1 credit. Majors, 300 concurrently. In-depth consideration of effect of communication.

315. Organisational Communication
Spring. 4(4-0) 101.
Principles and practices in the management of communication systems, with emphasis on conflict resolution, information exchange, innovativeness, and information management.