

**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.

**883. Chemical Kinetics**  
Spring. 3(3-0) 880.

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

**890. Problems and Reports**  
Fall, Winter, Spring, Summer. Variable credit. May re-enroll for a maximum of 12 credits. Approval of department.

**899. Research**  
Fall, Winter, Spring, Summer. Variable credit. May re-enroll for a maximum of 12 credits. Approval of department.

Research in inorganic, analytical, organic, and physical chemistry.

**908. 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, Winter, 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.

**956. Selected Topics in Organic Chemistry**  
Fall, Winter, Spring. 2(2-0) or 3(3-0) May re-enroll for a maximum of 12 credits if different topic is taken. Approval of department.

Topics may be selected from heterocyclic chemistry, natural products, free radicals, carbonium ions, organic sulfur or nitrogen compounds, acidity functions, isotope effects, photochemistry and others.

**958. Seminar in Organic Chemistry**  
Fall, Winter, Spring. 0 or 1(1-0)

Discussions of recent advances and reports by graduate students on research problems.

**985. Statistical Thermodynamics**  
Fall of odd-numbered years. Winter and Spring of even-numbered years. 3(3-0) May re-enroll for a maximum of 9 credits if different topic is taken. Approval of department.

Definition of partition function; translational, rotational, vibrational and electronic partition functions and their calculation and application to thermodynamic problems; application of spectroscopic measurements to thermodynamic calculations.

**987. Selected Topics in Physical Chemistry**  
Fall. 3(3-0) May re-enroll for a maximum of 6 credits if different topic is taken. Approval of department.

Mathematical preparation for quantum chemistry. Selected topics as: kinetics and photochemistry, macromolecular and surface chemistry, molecular spectroscopy, electro and magnetic properties of matter, application of statistical mechanics to chemical problems.

**988. Selected Topics in Physical Chemistry**  
Winter. 3(3-0) May re-enroll for a maximum of 9 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.

**991. Quantum Chemistry**  
Fall, Winter, Spring. 3(3-0) May re-enroll for a maximum of 9 credits if different topic is taken. Approval of department.

Principles of quantum chemistry and their application to chemical problems. Electronic structure of molecules and its correlation with the chemical and physical properties of substances. Emission and absorption of radiation.

**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.

## CHINESE

See Linguistics and Oriental and African Languages

## CIVIL AND SANITARY ENGINEERING

### College of Engineering

#### Civil Engineering C E

**251. Elementary Surveying**  
Fall, Spring. 4(3-3) 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.

**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.

Properties of soil and particulate materials, physics of clay water systems, effective stress and consolidation theory, soil strength theory, and introduction to problems of design and construction.

**321. Hydrodynamics**  
Winter, Spring. 5(4-2) MMM 206.

Fundamentals of flow of real fluid, fluid properties, kinematics, continuity, laminar and turbulent flow, form drag, stream lines, potential flow pipe and open channel flow.

**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, geometrics and traffic studies.

**346. Transportation**  
(446.) Fall. 3(3-0) MTH 214

Planning, design and evaluation of transportation systems. Operational characteristics of transportation modes, traffic flow and techniques for system selection.

**347. Transportation Facilities**  
(447.) Winter. 4(3-3) 215 or 252.

Geometric design of highway and airport facilities as these considerations affect capacity, traffic control and economics of transport systems. Financing and administration of transport systems.

**353. Surveying II**  
Fall, Spring. 4(3-3) 251 or 252.

Continuation of 252 including photogrammetric methods, astronomical observations for latitude, longitude and meridian. Introduction to geodetic methods.

- 370. Cost and Optimization Engineering**  
Fall. 3(3-0) MTH 113.  
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**  
Winter. 3(3-0) Juniors.  
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**  
Spring. 3(3-0) Juniors.  
The professional engineer's relationship with the legal aspects of engineering. Special emphasis on contract documents.
- 382. Environmental Engineering I—Hydrology and Water Supply**  
Spring, Summer. 4(3-2) 321; CEM 131 or 141.  
Hydrology of ground and surface waters. Hydraulic networks. Water supply and distribution systems. Water quality, control and treatment.
- 390. Civil Engineering Analysis**  
Fall, Winter. 3(3-0) MTH 215.  
Analysis of civil engineering problems by numerical and statistical methods. Approximate methods and error analysis. Application to computer use.
- 400. Structural Mechanics II**  
Spring, Summer. 4(4-0) 305.  
Energy methods in static and dynamic structural analysis, including the principles of virtual displacements and virtual forces. Influence lines. Matrix analysis of structures, influence and stiffness coefficients. Computer facilities are used.
- 405. Structural Design in Steel**  
Fall, Winter. 4(4-0) 305.  
Beams, columns, tension and compression members, connections. Elastic, plastic and ultimate strength concepts.
- 406. Structural Design in Concrete**  
Winter, Spring. 4(4-0) 305.  
Reinforced concrete beams, columns, slabs, footings and retaining walls. Elastic theory and ultimate strength concepts. Prestressed theory and design.
- 416. Structural Mechanics III**  
Fall. 4(4-0) 400.  
Beam-columns, elastic buckling, thin-walled members. Elementary theory with special reference to structures. Elements of plates and shells. Introduction to inelastic behavior of structures.
- 419. Soil Mechanics II**  
Fall. 4(4-0) 312.  
Elastic and plastic equilibrium in soil and rock masses, concepts of stability and soil-structure interactions. Applications to earth structures, bearing capacity and earth pressure problems.
- 421. Hydrology**  
Fall. 3(3-0) MTH 112, Juniors or approval of department.  
Meteorologic and hydrologic phenomena associated with the hydrologic cycle; precipitation, melting of snow and ice, streamflow, evaporation and evapotranspiration; observational and analytical methods; river forecasting, design applications.
- 422. Hydraulics**  
Spring. 4(3-2) 321.  
Pipes and pipe networks, open channel flow, flow measurements, hydraulic machinery, surges and water hammer.
- 448. Transportation Planning**  
Winter. 3(3-0) 342 or 346.  
Urban transportation facilities needs and programs. Design of transportation models for urban highways and public transit including trip generation, trip distribution, mode split and traffic assignment. Transport agencies function and services.
- 449. Highway Engineering**  
Spring. 3(2-2) 308, 347.  
Design concepts of roadways, facilities, drainage and pavement design. Maintenance, construction and supervision methods and procedures.
- 471. Scheduling Construction Activities**  
(871.) Winter. 3 credits. Approval of department.  
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.
- 483. Environmental Engineering II—Water Pollution and Pollution Control**  
Fall. 4(3-2) 321; CEM 131 or 141.  
Environmental contamination. Parameters of air and water pollution. Storm and waste water collection systems. Physical, chemical and biological treatment of waste water.
- 487. Environmental Engineering III—Water and Waste Water Analysis**  
Winter. 4(3-3) 483.  
Theoretical aspects of water quality. Chemical and physical parameters. Water bacteriology. Qualitative and quantitative measurements of contamination. Biochemical oxygen demand.
- 499. Civil Engineering Projects**  
Fall, Winter, Spring, Summer. Variable credit. May re-enroll for a maximum of 6 credits. Approval of department.  
Original civil engineering problem of specific interest to the student and a faculty member. Student's proposal describing problem required prior to approval.
- 800. Operations Research Techniques for Civil Engineers**  
Fall. 3(3-0) Graduate standing.  
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.
- 802. Structural Dynamics I**  
Winter. 3(3-0) 405, 406, or approval of department.  
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.
- 803. Structural Dynamics II**  
Spring. 3(3-0) 802.  
Dynamics of large scale structural systems. Network formulation and numerical methods. Behavior under random disturbances. Characterization of and response to random disturbances and failure criteria.
- 804. Advanced Structural Theory I**  
Winter. 4(4-0) 400, or approval of department.  
Energy principles and their application in the analysis of elastic structures. Advanced force and displacement methods and their matrix formulation. Introduction to finite element methods.
- 805. Advanced Theory of Reinforced Concrete I**  
Winter. 3(3-0) 406.  
Deflection, torsion, shrinkage, plastic flow, and ultimate strength of concrete structures. Prestressed concrete.
- 807. Model Analysis**  
Fall. 3(2-3) 406.  
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**  
Winter. 4(4-0) 347.  
Foundation problems as 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**  
Fall. 4(3-3) 419 or approval of department.  
Mechanical properties of soil including stress-strain behavior; conditions of failure and shear strength; consolidation theory and permeability. Laboratory determination of soil properties including interpretation of experimental data for use in practice.
- 818. Advanced Soil Mechanics**  
Winter. 4(4-0) 419; 817 recommended.  
Elastic and plastic equilibrium in soil masses, earth pressure and bearing capacity theories.
- 821. Flow of Fluids in Porous Media**  
Spring. 3(3-0) 422.  
Structure and properties of porous media. Fluid flow in saturated and unsaturated media. Two-phase flow. Darcy's and Navier Stokes equations. Two-dimensional sink flow. Multiple sources and sinks. Potential theory and conformal mapping. Permeability in an anisotropic medium.
- 828. Hydraulic Engineering I**  
Fall. 3(3-0) 422.  
Application of hydromechanics to hydraulic engineering; open channel flow, uniform flow and gradually varied flow, flood routing; supercritical flow in steep chutes, bends and transitions; hydraulic jump and structures for the dissipation of energy.
- 829. Hydraulic Engineering II**  
Winter. 3(3-0) 828.  
Continuation of applications of hydromechanics to hydraulic engineering problems: sub-critical flow in channel transitions and controls, spillways, gates, contractions, expansions, culverts; flow measurement; model studies, similitude, construction and instrumentation of models, interpretation and limitations of models.

**843. Traffic Engineering  
Characteristics**

Winter. 3(3-0) 346, STT 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 streams. Dispatching, scheduling and network analysis. Application to highways, airport operation and urban transportation modes.

**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(2-3) 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, Pucher's stress 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. Advanced Soil Mechanics II**

Spring. 3(3-0) 817 recommended.

Earth structures including natural and cut slopes, embankments and earth dams; mechanisms of flow slides, slope stability analysis and design problems, seepage applications including confined and unconfined flow of water through soils.

**916. Advanced Soil Mechanics III**

Summer. 3(3-0) 817.

Soil dynamics including design of foundations for machinery; effects of ground motion on earth slopes and earth dams; stress-strain behavior of soil during transient and repeated loadings; and relation of soil properties to wave velocity.

**999. Research**

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

**Sanitary Engineering**

**S E**

**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.

**806. Sewage Collection and  
Treatment**

Spring. 3(3-0) C E 483.

Chemical, physical and biological principles of sewage collection and treatment.

**899. Research**

(EGR 899.) 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**

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

**CLASSICAL STUDIES**

See Romance Languages

**COMMUNICATION COM**

**College of Communication Arts**

**100. Human Communication I**

Fall, Winter, Spring, Summer. 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, Summer. 3(3-0)

Continuation of 100, with greater emphasis on speaking and writing, and on analyzing increasingly complex communication situations.

**199. Methods of Inquiry**

Fall, Winter, Spring, Summer. 3(3-0) Majors and minors only. 101.

Major theoretic orientations toward communication. Primary tools of scholarly inquiry.

**205. Persuasion**

(305, S T 305.) Fall, Winter, Spring. 4(4-0) 101.

Process of influencing human behavior through persuasive communication. Experience in creating persuasive messages and in evaluating the acceptability of persuasive attempts.

**210. Leadership**

(116, S T 116.) Fall, Winter. 4(4-0)

Principles and practice in the utilization of communication for effective leadership.

**299. Individual Projects**

Fall, Winter, Spring, Summer. Variable credit. May re-enroll for a maximum of 15 credits. 199, approval of project proposal by department.

Independent research, experience in communication laboratories, or tutorial work in communication skills.

**300. Effects of Communication I**

Fall, Winter, Spring, Summer. 4(4-0)

100; majors must enroll in 300R concurrently. Examination of the dimensions of communication effects.

**300R. Effects of Communication II**

Fall, Winter, Spring, Summer. 1 credit. Majors. 300 concurrently.

In-depth consideration of effects of communication.

**315. Organizational Communication**

(311, S T 311.) Spring. 4(4-0) 101.

Principles and practice in the management of communication systems, with emphases on conflict resolution, information exchange, innovativeness, and information management.

**350. Signs and Sign-Behavior I**

Fall, Winter, Spring, Summer. 4(4-0)

100; majors must enroll in 350R concurrently. Theories of man's symbolic behaviors. Semiotics and general semantics.