

**836. Separations**  
Spring of odd-numbered years. 3(3-0)  
Approval of department.  
Physical and chemical methods of separation.

**837. Electroanalytical Chemistry**  
Spring of even-numbered years. 3(3-0)  
Approval of department.  
Theory and applications of modern electroanalytical chemistry to chemical and biomedical problems. Coulometry, electrometric titrations, ion-selective voltammetry; electrochemical synthesis and preparation of species for spectroscopy; trace analysis.

**838. Scientific Instrumentation**  
Fall, Spring, Summer. 2(1-3) to 4(2-6)  
May reenroll for a maximum of 10 credits. Approval of department.  
Scientific measurements. Principles and applications of servo systems, operational amplifiers, linear and digital solid state devices, analog, digital and hybrid instrumentation systems, and minicomputers for scientific measurements.

**844. Structural Elucidation by Instrumental Methods**  
Fall. 3(3-0) Approval of department.  
A practical instrumental analysis course with the major emphasis on the interpretation of data rather than a detailed description of the instrumentation. The fundamental principles behind the various measurements will be discussed in a general way, and important instrumental limitations will be noted.

**860. Organic Reactions: A Mechanistic Approach**  
Fall. 3(3-0) CEM 353; CEM 462 or approval of department.  
Organic reactions are presented in a mechanistic framework. Reactions which proceed via carbonocations, carbanions, free radicals, carbenes, arynes and other reactive intermediates, and concerted reactions are included.

**861. Structure of Organic Compounds**  
Winter. 3(3-0) CEM 860 or approval of department.  
Structural and stereochemical principles will be developed and illustrated. Spectroscopic data will be used to illustrate the principles and to determine structure, with an emphasis on nuclear magnetic resonance spectroscopy.

**862. Advanced Synthetic Organic Chemistry**  
Spring. 3(3-0) CEM 860 or approval of department.  
The strategy and methods of organic synthesis will be discussed.

**880. Atomic and Molecular Structure**  
Fall. 3(3-0) CEM 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) CEM 880.  
Rates and mechanisms of chemical reactions, reaction rate theory, kinetic theory of gases, photochemistry.

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

**899. Master's Thesis Research**  
Fall, Winter, Spring, Summer. Variable credit. Approval of department.  
Research in inorganic, analytical, organic, and physical chemistry.

**913. Selected Topics in Inorganic Chemistry**  
Fall, Spring, 3(3-0) May reenroll 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 nonaqueous solvents.

**918. Seminar in Inorganic Chemistry**  
Fall, Winter, Spring. 1(2-0) May reenroll for a maximum of 3 credits.  
Discussions of recent advances and reports by graduate students on research problems.

**924. Selected Topics in Analytical Chemistry**  
Fall, Winter, Spring. 3(3-0) or 2(2-0) May reenroll for a maximum of 9 credits if different topic is taken.  
Among topics which may be discussed are: advances in electroanalytical chemistry or spectroscopy; nonaqueous solvents; complexation equilibria; surface chemistry; analytical chemistry of polymers.

**938. Seminar in Analytical Chemistry**  
Fall, Winter, Spring. 1(1-0) May reenroll for a maximum of 3 credits.  
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 reenroll 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. 1(2-0) May reenroll for a maximum of 3 credits.  
Discussions of recent advances and reports by graduate students on research problems.

**985. Statistical Thermodynamics**  
Winter of even-numbered years. Spring. 3(3-0) May reenroll for a maximum of 9 credits if different topic is taken. Approval of department.  
Partition functions, spectroscopic measurements and thermodynamic applications. Nonequilibrium statistical mechanics and thermodynamics. Time correlation functions and spectroscopic lineshapes, light scattering, and magnetic relaxation. Transport properties of fluids and gases.

**987. Selected Topics in Physical Chemistry**  
Fall, Winter. 3(3-0) May reenroll for a maximum of 9 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, Spring. 3(3-0) May reenroll 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. Selected Topics in Quantum Chemistry**  
Fall, Winter. 3(3-0) May reenroll for a maximum of 9 credits if different topic is taken. Approval of department.  
Principles of quantum mechanics and application to chemical problems. Selected topics from spectroscopy, properties of atoms and molecules in electric and magnetic fields, and theories of molecular electronic structure.

**998. Seminar in Physical Chemistry**  
Fall, Winter, Spring. 1(1-0) May reenroll for a maximum of 3 credits.  
Discussions of recent advances and reports by graduate students on research problems.

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

## CHINESE

See Linguistics and Germanic, Slavic, Asian and African Languages.

## CIVIL AND SANITARY ENGINEERING

### College of Engineering

#### Civil Engineering

C E

**251. Elementary Surveying**  
Fall, Spring. 4(3-3) 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) Engineering majors or approval of department.  
Instruments, theory of measurements, error analysis, stadia, horizontal and vertical curves, U.S. Public Land System, observation for meridian.

**280. Introduction to Environmental Engineering**  
Fall, Winter, Spring. 4(4-0) CEM 141, or CEM 131, MTH 112, CPS 120.  
Hydrology; ground water and surface water supply systems; wastewater treatment, methods of pollution control for solid waste, air, and noise.

**Descriptions – Civil and Sanitary Engineering  
of  
Courses**

- 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 of odd-numbered years. 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, Spring. 5(4-2) MMM 306.*  
Fluid properties; hydrostatics; control volume approach to conservation of mass, momentum and energy; dimensional analysis and dynamic similitude; 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, geometrics and traffic studies.
- 346. Transportation**  
*Winter, Spring, Summer. 3(3-0) MTH 113.*  
Planning, design and evaluation of transportation systems. Operational characteristics of transportation modes, traffic flow and techniques for system selection.
- 347. Transportation Facilities**  
*Fall, Winter. 4(3-3) C E 252.*  
Geometric design of highways and airports as these considerations affect capacity, construction costs, financing and safety.
- 353. Surveying II**  
*Spring. 4(3-3) C E 251 or C E 252.*  
Continuation of C E 252 including photogrammetric methods, astronomical observations for latitude, longitude and meridian. Introduction to geodetic methods.
- 370. Cost and Optimization Engineering**  
*Fall, Winter. 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**  
*Fall, Spring. 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.
- 390. Civil Engineering Analysis**  
*Fall, Spring. 4(4-0) MTH 310, CPS 120.*  
Analysis of civil engineering problems by numerical and statistical methods. Approximate methods and error analysis. Application to computer use.
- 400. Structural Mechanics II**  
*Fall, Summer. 4(4-0) C E 305, C E 390.*  
Miscellaneous topics in displacement calculation by virtual work. Matrix formulation of the general principles of framed structural analysis. Exhaustive study of the flexibility and stiffness methods.
- 405. Structural Design in Steel**  
*Fall, Winter. 4(4-0) C E 305, C E 390.*  
Beams, columns, tension and compression members, connections. Elastic, plastic and ultimate strength concepts.
- 406. Structural Design in Concrete**  
*Winter, Spring. 4(4-0) C E 305, C E 308, C E 390.*  
Reinforced concrete beams, columns, slabs, footings and retaining walls. Elastic theory and ultimate strength concepts. Prestressed theory and design.
- 407. Structural Design Concepts**  
*Spring. 3(3-0) C E 405, C E 406.*  
Develop and expand design concepts through study, investigation and project design of various structural systems. Criteria for material selection and creative design of unusual structural systems pursued.
- 410. Structural Mechanics III**  
*Winter. 4(4-0) C E 400, CPS 120.*  
Continuation of C E 400. Matrix analysis of framed structures. Introduction to inelastic behavior of structures. Use of programmed computer solution techniques.
- 419. Soil Mechanics II**  
*Fall, Spring. 4(4-0) C E 312, C E 390.*  
Foundation engineering. Immediate, consolidation, and secondary settlements; stress distribution in soil masses; lateral earth pressures on structures; bearing capacity of shallow foundations; introduction to stability analysis of earth structures.
- 421. Hydrology**  
*Spring. 4(3-2) C E 280, C E 321, C E 390.*  
Engineering hydrology; frequency and precipitation analysis; streamflow analysis and the unit hydrograph; flood prediction; rainfall-runoff correlations; urban hydrology.
- 422. Hydraulic Systems**  
*Fall, Winter. 4(3-2) C E 321, C E 390 or M E 351.*  
Steady flow in pipe networks; open channel flow; turbomachinery; groundwater hydraulics; introduction to unsteady flows. Applications to water supply systems; aquifer analysis; surges and water hammer.
- 441. Highway Operations.**  
*Fall. 3(3-0) C E 346 or C E 342, C E 390.*  
Driver and vehicle characteristics affecting traffic flow; traffic flow density, headway and speed measurements; signing and signal control for efficient intersection operation, parking characteristics and capacity analysis.
- 442. Airport Planning and Design**  
*Fall, Spring. 4(3-2) C E 346, C E 390.*  
The planning and design of the components of the airport system including ground access facilities; aircraft characteristics; the air traffic control system; airport configuration; capacity analysis; management systems.
- 448. Transportation Planning**  
*Winter. 3(3-0) C E 342 or C E 346, C E 390.*  
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(3-0) C E 308, C E 347, C E 390.*  
Design concepts of roadways, facilities, drainage and pavement design. Maintenance, construction and supervision methods and procedures.
- 471. Scheduling Construction Activities**  
*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.
- 481. Water and Wastewater Analysis**  
*Fall. 4(3-3) C E 280, C E 390.*  
Quantitative analysis; bacteriologic and chemical characteristics of water and wastewater; principles of softening, iron removal, coagulation and chlorination; laboratory examination of water and wastewater including turbidity, solids, coliforms, chlorine, etc.
- 483. Water and Wastewater Treatment**  
*Spring. 4(3-2) C E 280, C E 422. Not open to graduate majors in sanitary engineering.*  
Water treatment theory and design including sedimentation, coagulation, softening, iron removal and chlorination; wastewater treatment theory and design including grit chambers, activated sludge, trickling filter, and anaerobic digesters.
- 485. Environmental Health Engineering**  
*Winter. 4(3-2) MPH 200, C E 280, C E 321, C E 390.*  
Design of small water, waste water and solid waste facilities. Epidemiology of communicable disease transmission by air, water, food and arthropods. Engineering measures to control disease spread.
- 494. Civil Engineering Design Project**  
*Fall, Winter, Spring. 3(2-2) Seniors, approval of department.*  
Planning, specifications and design of a civil engineering project or facility.

- 499. Civil Engineering Projects**  
Fall, Winter, Spring, Summer. Variable credit. May reenroll 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.
- 802. Structural Dynamics I**  
Fall. 3(3-0) C E 405, C E 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.
- 804. Advanced Structural Theory I**  
Winter. 4(4-0) C E 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) C E 406. Deflection, torsion, shrinkage, plastic flow, and ultimate strength of concrete structures. Prestressed concrete.
- 807. Model Analysis**  
Fall. 3(2-3) C E 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.
- 809. Finite Element Method**  
Fall. 4(4-0) Approval of department. Interdepartmental with the departments of Metallurgy, Mechanics and Materials Science and Agricultural Engineering. Administered by the Department of Metallurgy, Mechanics and Materials Science. Theory and application of the finite element method to the solution of continuum type problems in heat transfer, fluid mechanics and stress analysis.
- 812. Rock Mechanics**  
Fall of odd-numbered years. 3(3-0) MMM 211; C E 312. Engineering classification of rocks. Behavior of rocks under compressive, tensile and shear loads. Failure criteria. Design of openings in rock. Modes and mechanics of failure of rock slopes.
- 815. Principles of Highway and Airport Soils**  
Fall. 4(4-0) C E 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) C E 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) C E 419; C E 817 recommended. 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.
- 819. Soil Stabilization in Geotechnical Engineering**  
Summer. 3(3-0) C E 419. Techniques to improve the performance of soil in engineering applications; compactions, blending, admixture, grouting, electroosmosis, vibroflotation, compaction piles, thermal treatment, load bearing and hydraulic fills, precompression, reinforced earth.
- 820. Geotechnical Engineering for Cold Regions**  
Spring. 3(3-0) C E 419 or approval of department. Physical and thermal properties of ice and frozen soils; ground thermal regime; mechanical properties of frozen ground; thaw consolidation problems; foundation design; slope stability problems; and artificial freezing for construction.
- 821. Flow of Fluids in Porous Media**  
Fall. 4(4-0) C E 422 or approval of department. 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.
- 827. Environmental Fluid Mechanics**  
Spring of even-numbered years. 4(4-0) C E 422 or approval of department. Review of turbulent flow and transport processes in water quality control. Analysis and solution of ecological problems related to diffusion and disposal in rivers, estuaries, lakes and the ocean environment.
- 828. Open Channel Flow**  
Winter. 3(3-0) C E 422 or approval of department. Fundamentals of free surface flow; steady uniform and nonuniform concepts; energy and momentum principles; subcritical and supercritical regimes; gradually and rapidly varied flow; design applications.
- 829. Fluid Transients**  
Spring of odd-numbered years. 4(4-0) C E 828 or approval of department. Interdepartmental with the Department of Mechanical Engineering. Application of unsteady flow concepts and wave mechanics to hydraulic engineering; method of characteristics; surges and waterhammer in piping systems; unsteady open channel flow; oscillatory waves; similitude and models.
- 830. Intermediate Fluid Mechanics**  
Fall. 3(3-0) M E 332 or C E 321. Interdepartmental with and administered by the Department of Mechanical Engineering. Deformable control volumes, Navier-Stokes equations, dimensionless variables, vorticity and circulation, turbulent flow, inviscid flow, and boundary layer theory.
- 840. Pavement Design**  
Spring of even-numbered years. 3(3-0) C E 449. Pavement types and wheel loads, stresses in flexible pavements, stresses in rigid pavements, pavement behaviors under loadings; climate effects on pavement performance, evaluating subsoil strengths, subgrades, and pavement design criteria.
- 841. Optimization of Urban Traffic Flow**  
Fall of odd-numbered years. 3(3-0) Approval of department. Interdepartmental with and administered by Systems Science. Traffic flow models used in design of computerized traffic control systems. Optimal freeway ramp metering algorithms. Offline and online optimization of traffic signal timing.
- 842. Pavement Rehabilitation**  
Spring of odd-numbered years. 4(4-0) C E 449. Strengthening existing pavements, pavement overlay design criteria, epoxy and polyester resin repair and rehabilitation, evaluation of resurfacing practices for bituminous and cement pavements.
- 843. Traffic Engineering Characteristics**  
Winter of odd-numbered years. 3(3-0) C E 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 of odd-numbered years. 3(3-0) C E 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.
- 845. Environmental Impacts of Transportation Facility Design Decisions**  
Spring of even-numbered years. 3(3-0) C E 342 or C E 346, C E 448; or approval of department. The context in which current transportation planning and design decisions are made; legislation; socio-economic effects; air, noise, and water pollution. Preparation of environmental impact statements.
- 846. Highway Planning**  
Fall of odd-numbered years. 3(3-0) C E 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 of even-numbered years. 3(3-0) C E 347. Design of streets and highways including intersections, parking facilities, capacity, channelization and roadway appurtenances.
- 848. Transportation Models**  
Spring of odd-numbered years. 3(3-0) C E 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.

**Descriptions – Civil and Sanitary Engineering  
of  
Courses**

**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 C E 899 or C E 999.

**899. Master's Thesis Research**  
Fall, Winter, Spring, Summer. Variable credit. Approval of department.

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

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

**909. Elastic Thin Shells**  
Spring. 4(4-0) C E 804 or MMM 815 or approval of department; MTH 421. Interdepartmental with the Department of Metallurgy, Mechanics and Materials Science.  
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) C E 804 or MMM 815 or approval of department; MTH 422. Interdepartmental with and administered by the Department of Metallurgy, Mechanics and Materials Science.  
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 Structure**  
Spring. 3(3-0) C E 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. 4(4-0) C E 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.

**941. Mass Transit Routing and Scheduling**  
Fall of even-numbered years. 3(3-0) C E 848 or approval of department.  
Routing algorithms for mass transit vehicles in urban networks; dispatching of vehicles by dynamic programming and other algorithms; variable headway, variable route transit system studies.

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

**Sanitary Engineering S E**

**800. Environmental Engineering Seminar**  
Fall, Winter, Spring. 1(1-0) May reenroll for a maximum of 3 credits. Graduate major in C E or S E.  
Current research, reports, and literature reviews.

**802. Physical Chemical Processes of Environmental Engineering**  
Fall. 5(4-3) C E 481, C E 483 or concurrently.  
Analysis of physical and chemical principles which form the basis of air and water pollution control and solid waste disposal; process dynamics, sedimentation, coagulation, filtration, adsorption, absorption, oxidation.

**804. Biological Processes of Environmental Engineering**  
Winter. 4(4-0) MPH 200, S E 802.  
Aerobic and anaerobic degradation of liquid and solid wastes. Biochemical reactions; activated sludge and trickling filter kinetics; sludge digestion and composting.

**812. Water Treatment Plant Design**  
Winter. 4(3-3) C E 370, C E 483, C E 828, S E 802.  
Theory and design of water treatment processes. Coagulation and flocculation; softening; sedimentation; filtration; disinfection.

**814. Wastewater Treatment Plant Design**  
Spring. 4(3-3) C E 370, C E 483, C E 828, S E 804.  
Theory and design of wastewater treatment processes. Racks, screens, sedimentation basins, trickling filters, aeration tanks, digesters.

**816. Treatment of Industrial Wastes**  
Spring. 4(3-3) S E 804.  
Theory of industrial waste management. Application of physico-chemical and biological treatment to selected industries. Examples include: apparel; food processing; materials processing and chemical industry.

**822. Air Resource Management**  
Fall of even-numbered years. 4(4-0) S E 802 or concurrently.  
Characteristics of air contaminants and noise; sources and source inventory; microclimatology and pollutant transport; pollutant effects, introduction to sampling and control.

**880. Special Problems in Environmental Engineering**  
Fall, Winter, Spring, Summer. 1 to 6 credits. May reenroll for a maximum of 12 credits in C E 880 and S E 880 combined. Approval of department.  
Solution of environmental engineering problems, of limited scope not pertaining to thesis.

**899. Master's Thesis Research**  
Fall, Winter, Spring, Summer. Variable credit. Approval of department.

**922. Air Pollution Control**  
Winter of odd-numbered years. 4(3-3) C E 321, S E 802, S E 822.  
Application of physical and chemical principles to control of gaseous and particulate air pollutants. Cyclones, bag houses, electrostatic precipitators, adsorption, absorption, combustion.

**924. Air Sampling and Analysis**  
Spring of odd-numbered years. 4(3-3) S E 922.  
Theory and design of air sampling programs. Quantitative analysis of ambient air samples and stack samples. Analysis for sulfur oxides, nitrogen oxides and particulates.

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

**CLASSICAL STUDIES**

See Romance and Classical Languages.

**COMMUNICATION COM**

**College of Communication Arts and Sciences**

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

**115. Oral Communication**  
Fall, Winter, Spring, Summer. 3(3-0) COM 100 or approval of department.  
Principles and practice in adapting to audiences, creating and structuring messages, and developing effective delivery of formal and informal speeches. Critical evaluation of speeches by instructor and peers.

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

**205. Persuasion**  
Fall, Winter, Spring, Summer. 4(4-0) COM 101.  
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, Spring, Summer. 4(4-0) COM 100.  
Principles and practice in the utilization of communication for effective leadership.

**299. Individual Projects**  
Fall, Winter, Spring, Summer. Variable credit. May reenroll for a maximum of 15 credits. COM 199, approval of project proposal by department.  
Independent research, experience in communication laboratories, or tutorial work in communication skills.