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, potentiometric titrations, non-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 servosystems, 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.

Fall. 3(3-0) CEM 353; CEM 462 or approval of department.
Organic reactions are presented in a mechanistic framework. Reactions which proceed via carbonizations, carbones, free radicals, carbones, 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 rates theory, kinetic theory of gases, photochemistry.
305. Structural Mechanics I
Winter, Spring, 4(4-0) MTH 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) MTH 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) MTH 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, 4-0) MTH 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.

346. Transportation
Winter, Spring, Summer, 3(3-0) MTH 310.
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.

350. Surveying II
Spring, 4-0) 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) C E 300. 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 calculations 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 390.

407. Structural Design Concepts
Spring, 3(3-0) C E 405, C E 496.
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 305, C E 390.
Continuation of C E 305. 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; turbines; artificial waves; groundwater hydraulics; applications to water supply systems; aquifer analysis; surges and water hammer.

441. Highway Operations
Fall, 3(3-0) C E 340 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, modal split and traffic assignment. Transport agencies function and services.

449. Highway Engineering
Spring, 3(3-0) C E 368, 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.

451. Water and Wastewater Analysis
Fall, 4(3-0) C E 290, C E 390.
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, coliforms, chlorine, etc.

453. Water and Wastewater Treatment
Spring, 4(3-2) C E 290, 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.

455. Environmental Health Engineering
Winter, 4(3-2) MTH 300, C E 280, C E 381, C E 390.
Design of small 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) Juniors. Approval of department.
Planning, specifications and design of a civil engineering project or facility.
805. AdtJanced Including Metallurgu, Interdepartmental slopes. and airports, relation of subsoil analysis of elastic
lems in d}llalllic
partment.

807. Model Analysis
Fall. 3(2-0) C E 406.
Basic theory of the analysis of structures by means of models. Laboratory work on models; Begg's defo
mer 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.

815. Principles of Highways and Airport Soils
Fall. 4(4-0) C E 347.
Foundation problems as related to highways and airports, relation of subsid 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 caisfords.

819. Soil Stabilization in Geotechnical Engineering
Summer. 3(3-0) C E 419.
Techniques to improve the performance of soil in structural applications, compactions, blending, admixture, grouting, earthcons, 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.

822. 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 pollution and disposal in rivers, estuaries, lakes and the ocean environment.

823. 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; waves and waterhammer in piping systems; unsteady open channel flow; oscillatory waves; similitude and models.

824. 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 evolution of system alternatives.
Descriptions – Civil and Sanitary Engineering

Courses

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

809. Master’s Thesis Research
Fall, Winter, Spring, Summer. Variable credit. Approval of department.

905. Advanced Theory and Design of Reinforced and 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(0-0) C E 804 or M M M 815 or approval of department; M T H 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(0-0) C E 804 or M M M 815 or approval of department; M T H 422. Interdepartmental with and administered by the Department of Metallurgy, Mechanics and Materials Science.
Behavior 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(0-0) 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

800. Environmental Engineering Seminar
Fall, Winter, Spring. 1(1-0) May be repeated 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. 3(3-3) 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, filtration, adsorption, absorption, oxidation.

804. Biological Processes of Environmental Engineering
Winter. 4(4-0) M P H 200, S E 862.
Acrobic 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
Theory and design of water treatment processes. Coagulation and flocculation; softening; sedimentation; filtration; disinfection.

814. Wastewater Treatment Plant Design
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 physio-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 pollutants and noise; sources and control; 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 be repeated for a maximum of 15 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 806, S E 922.
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. Qualitative analysis of ambient air samples and stack samples. Analysis of sulfur oxides, nitrogen oxides and particulates.

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

CLASSICAL STUDIES

See Romance and Classical Languages.

COMMUNICATION

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 speech. Critical evaluation of speeches by instructor and peers.

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

265. 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. 3(3-0) COM 100.
Principles and practice in the utilization of communication for effective leadership.

299. Individual Projects
Fall, Winter, Spring, Summer. Variable credit. May be repeated 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.