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(1-0) May reenroll for a maximum of 9 credits if different topic is taken.
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 9 credits.
Discussions of recent advances and reports by graduate students on research problems.

946. Selected Topics in Physical Chemistry
Fall, Winter, Spring. 3(3-0) May reenroll for a maximum of 9 credits if different topic is taken.
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.

956. Selected Topics in Organic Chemistry
Fall, Winter, Spring. 2(2-0) or 3(3-0) May reenroll for a maximum of 13 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(1-0) May reenroll for a maximum of 3 credits.
Discussions of recent advances and reports by graduate students on research problems.

965. 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.

995. Selected Topics in Physical Chemistry
Fall, 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.

992. Doctoral Dissertation 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

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. 4(3-3) 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.

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 II
Spring, Summer. 4(3-3) MMM 211.
Engineering properties of soils and their measurements. 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. 3(3-2) MMM 206.
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, geometries and traffic studies.

346. Transportation
Fall, Winter, 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
Winter. 3(3-3) C E 251 or C E 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
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.
422. Hydraulic Systems
Winter, 4(3-2) C E 321, C E 390 or M E 351.

441. Highway Operations
Spring, 3(3-0) C E 346 or C E 342.

442. Airport Planning and Design
Fall, 4(3-2) C E 346.

443. Transportation Planning
Winter, 3(3-0) C E 342 or C E 346.

444. Highway Engineering
Spring, 3(2-2) C E 308, C E 347.

471. Scheduling Construction Activities
Winter, 3 credits. Approval of department.

481. Water and Wastewater Analysis
Fall, 4(3-2) C E 250.

482. Water and Wastewater Treatment
Spring, 4(3-2) C E 280, C E 421, C E 422 or concurrently. Not open to graduate majors in sanitary engineering.

485. Environmental Health Engineering
Winter, 3(3-0) MPH 200, C E 280, C E 321, C E 390.

499. Civil Engineering Projects
Fall, Winter, Spring, Summer. Variable credit. May enroll for a maximum of 6 credits. Approval of department.

800. Operations Research Techniques for Civil Engineers
Fall, 3(3-0) Graduate standing.

804. Advanced Theory of Reinforced Concrete I
Winter, 4(4-0) C E 400, or approval of department.

805. Advanced Theory of Reinforced Concrete II
Winter, 4(4-0) C E 406.

806. Structural Dynamics I
Fall, 3(3-0) C E 405, C E 406, or approval of department.

807. Model Analysis
Fall, 3(3-0) C E 406.

809. Finite Element Method
Fall. 4(4-0) Approval of department.

815. Principles of Highway and Airport Soils
Winter, 4(4-0) C E 347.

817. Mechanical Properties of Soils
Fall, 4(3-3) C E 419 or approval of department.

818. Advanced Soil Mechanics
Winter, 4(4-0) C E 419; C E 817 recommended.
819. Soil Stabilization in Geotechnical Engineering
Spring. 3(3-0) C E 419.
Techniques to improve the performance of soil in engineering applications; compactions, blending, admixture, grouting, electromechanical, 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.

823. 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; gradual and rapidly varied flow; design applications.

824. Fluid Transients
Spring. of odd-numbered years. 4(4-0) C E 423 or approval of department.
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; similarity and models. For students interested in fluid mechanics.

825. 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.

826. 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 freeways ramp metering algorithms. Offline and online optimization of traffic signal timing.

827. Environmental Fluid Mechanics
Spring. of even-numbered years. 4(4-0) C E 422 or approval of department.

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; gradual and rapidly varied flow; design applications.

829. Fluid Transients
Spring. of odd-numbered years. 4(4-0) C E 423 or approval of department.
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; similarity and models. For students interested in fluid mechanics.

830. 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.

831. 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 freeways ramp metering algorithms. Offline and online optimization of traffic signal timing.

832. 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.

833. Traffic Engineering Characteristics
Winter. 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.

834. Traffic Engineering Theory and Control
Spring. 3(3-0) C E 434.
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.

835. Environmental Impacts of Transportation Facility Design
Spring. 3(3-0) C E 342 or C E 346, C E 445, or approval of department.
The context in which current transportation planning and design decisions are made; legislation; socioeconomic effects; air, noise, and water pollution. Preparation of environmental impact statements.

836. Highway Planning
Fall. 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.

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

838. Transportation Models
Spring. 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.

839. 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.

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

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

842. Advanced Structural Steel Design
Spring. 3(3-0) C E 406.
Analysis and design of multi-structure building frames; continuous trusses and rigid-frame girders bridges in structural steel. Plastic design.

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

844. Theory of Plates
Winter. 4(4-0) C E 804 or MMM 815 or approval of department; MTH 422. Independent 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.

845. Earth Structure
Spring. 3(3-0) C E 417 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.

846. Soil Dynamics
Winter. 4(4-0) C E 417 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.

847. Mass Transit Routing and Scheduling
Fall of even-numbered years. 3(3-0) C E 548 or approval of department; MTH 421. Independent with the Department of Metallurgy, Mechanics and Materials Science.
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.

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

Sanitary Engineering

849. Physical Chemical Processes of Environmental Engineering
Fall. 4(4-0) C E 491, C E 493 or concurrent.
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.

850. Biological Processes of Environmental Engineering
Fall. 4(4-0) C E 401, C E 402, C E 403.
Aerobic and anaerobic degradation of liquid and solid wastes. Biocatalytic 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
(806.) Spring. 4(3-3) C E 370, C E 485, C E 829, S E 804.
Theory and design of wastewater treatment processes. Racks, screens, sedimentation basins, trickling filters, aeration tanks, digesters.

816. Treatment of Industrial Wastes
(803.) 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 enroll 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.

119. Methods of Inquiry
Fall, Winter, Spring, Summer. 3(3-0)
Majors and minors only. COM 101.
Major theoretical 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 101.
Principles and practice in the utilization of communication for effective leadership.

299. Individual Projects
Fall, Winter, Spring, Summer. Variable credit. May enroll for a maximum of 15 credits. COM 198, approval of project proposal by department.
Independent research, experience in communication laboratories, or tutorial work in communication skills.

300. The Effects of Mass Communication I
Fall, Winter, Spring, Summer. 4(3-0)
Majors must enroll in COM 350R 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, Summer. 1 credit.
Majors. COM 300 concurrently.
In-depth consideration of effects of communication.

315. Organizational Communication
Fall, Winter, Spring. 4(4-0) COM 101.
Principles and practice in the management of communication systems, with emphasis on conflict resolution, information exchange, innovativeness, and information management.

326. Communication in Business
(BIO 326.) Fall, Winter, Spring, Summer. 4(3-0) Juniors.
Study and analysis of business and industrial communication problems; extensive instruction and practice in writing.

350. Signs and Sign Behavior I
Fall, Winter, Spring. 4(4-0)
COM 100; majors must enroll in COM 350R concurrently.
Theories of man's symbolic behaviors. Semiotics and general semantics.

350R. Signs and Sign Behavior II
Fall, Winter, Spring, Summer. 1 credit.
Majors. COM 350 concurrently.
In-depth consideration of signs and sign behavior.

351. Message Analysis
Winter. 4(4-0) COM 350.
Methods of describing messages and message codes, with emphasis on the concept of information.

352. Non-Verbal Communication
Spring. 4(4-0) COM 350.
Continuation of COM 351, with emphasis on non-verbal codes: gesture, expression, time and space, light.

360. Critical Perspectives on Communication
Fall, Winter, Spring. 4(4-0) COM 100.
Interdependence of communication and other societal factors, emphasizing criteria for ethical and social appropriateness.

399. Special Topics in Communication
Fall, Winter, Spring. 4(4-0)
May reenroll for a maximum of 8 credits. Juniors.
Contemporary issues in communication.

405. Quantitative Strategies in Communication Research
Fall, Spring. 3(3-0)
Seniors.
Design and statistical strategies in communication research. Project design and evaluation schema. Basic data handling and presentation.

410. Classroom Communication
Spring. 3(3-0) Majors and minors or approval of department.
Classroom as a communication system with emphasis on operationalizing philosophies of education in the environment, teacher and student roles and styles, affective and cognitive interactions, methods of systematic observation.

411. Directing the Debate and Forensic Program
Fall. 3(3-0) Majors and minors or approval of department.
Principles of and practice in argumentation; methods of coaching debate and individual events and managing tournaments; observation of high school tournaments, practices, and student congress.

413. Seminar in Communication Education
Fall. Winter. Summer. 4(4-0) ED 327.
Philosophies of curricular and co-curricular programs in communication education. Internship experience in those programs.

420. Message Design
Winter. 4(4-0) COM 191.
Principles and practice in message-media construction and selection.

499. Special Projects
Fall, Winter, Spring. Variable credit. May reenroll for a maximum of 15 credits. Approval of project proposal by department.
Independent research, group research, student-directed group projects.