918. Seminar in Inorganic Chemistry  Fall, Winter, Spring. 1(0-0) 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; carbenium 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 8 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 6 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 Oriental 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 130. 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) 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. 5(4-2) MTH 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) Jr.; Seniors.
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.

405. Structural Mechanics II
Fall, Summer. 4(4-0) C E 305, C E 390.
Micellaneous topics in displacement calculation by investigation and project design of general principles of framed structural analysis. Exhaustive study of the flexibility and stiffness methods.

406. Structural Mechanics III
Winter, Spring. 4(4-0) C E 305, C E 390.

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 405. Matrix analysis of framed structures. Introduction to inelastic behavior of structures. Use of programmed computer solution techniques.

415. 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 306, 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 321. 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 gut 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) Juniors, approval of department.
Planning, specifications and design of a civil engineering project of facility.

499. Civil Engineering Projects
Fall, Winter, Spring. 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.

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. Pressurized concrete.

807. Model Analysis
Fall. 4(4-0) Approval of department.
Intermediate 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.

815. Principles of Highway and Airport Soils
Fall. 4(4-0) C E 347.
Foundation problems related to highways and airports, relation of subsoil conditions to design and construction, analytical review of laboratory and field results.

817. Mechanical Properties of Soils
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 415.
Techniques to improve the performance of soil in engineering applications; compaction, blending, admixture, grouting, electro-osmosis, 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.

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 fluid 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 526 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; similarity 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.

844. Traffic Engineering Theory and Control
Spring of odd-numbered years. 4(4-0) C E 449.
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 problems 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.
Sanitary Engineering S E

800. Environmental Engineering Seminar
Fall, Winter, Spring. 1(1-0) May reenroll for a maximum of 2 credits. Graduate major in C E or S E.
Current research, reports, and literature reviews.

802. Physical Chemical Processes of Environmental Engineering
Fall. 3(3-1) CE 481, CE 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(3-1) CE 370, CE 483, CE 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(3-1) CE 370, CE 483, CE 828, S E 804.
Theory and design of wastewater treatment processes. Tanks, screens, sedimentation basins, trickling filters, aeration tanks, digesters.

816. Treatment of Industrial Wastes
Spring. 4(3-1) S E 804.
Theory of industrial waste management. Application of physico-chemical and biological treatment to specific industries. Examples include: apparel; food processing; 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 inventories; 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, absorption, adsorption, 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. 3(3-0).
Process and functions of communication. Principles underlying communication behavior. Practice in analyzing communication situations and in speaking and writing.

101. Human Communication II
Fall, Winter, Spring. 3(3-0) 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. 3(3-0) COM 100 or approval of department.
Principles and practice in adapting to audience, 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 theoretical orientations toward communication. Primary tools of scholarly inquiry.

205. Persuasion
Fall, Winter, Spring. 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. 4(4-0) COM 106.
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.

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

300R. Effects of Communication II
Fall, Winter, Spring. 4(4-0) COM 301.
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
Fall, Winter, Spring. 4(4-0) 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. 4(4-0) 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
Fall 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 190.
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. 5(5-0) Seniors.
Design and statistical techniques in communication research. Project design and evaluation schema. Basic data handling and presentation.