983. Chemical Kinetics
Spring 3(3-0) CEM 880.
Rates and mechanisms of chemical reactions, reaction rate theory, kinetic theory of gases, photochemistry.

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

990. 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(1-0) 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 spectrocop-try; 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, 3(3-0) or 2(2-0) May reenroll for a maximum of 12 credits if different topic is taken.
Topics may be selected from heterocyclic chemistry, natural products, free radicals, carbon- ion chemistry, 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.

959. 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.

972. Selected Topics in Quantum 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.

978. Seminar 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 of quantum mechanics and applications to chemical problems. Selected topics from spectroscopy, properties of atoms and molecules in electric and magnetic fields, and theories of molecular electronic structure.

911. 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.
Discussions of recent advances and reports by graduate students on research problems.

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

CHINESE
See Linguistics and Oriental and African Languages.

CIVIL AND SANITARY ENGINEERING

College of Engineering

Civil Engineering

C E

251. Elementary Surveying
Fall, Spring, 3(3-0) Trigonometry, EGR 160 or EGR 207. 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, 3(3-0) Trigonometry.
Instruments, theory of measurements, error analysis, stadia, horizontal and vertical curves, U.S. Public Land System, observation for meridian.
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 215 and 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.
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.
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.

407. Structural Design Concepts
Spring. 3(3-0) C E 405, C E 406.
Develop and expand design concepts through study, analysis, 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. 4(4-0) C E 312.
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
Fall, Spring. 4(3-2) C E 380, 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
Winter. 4(3-2) C E 321, C E 390 or M E 351.
Steady flow in pipe networks; open channel flow; turbulence; groundwater hydraulics; introduction to unsteady flows. Applications to water supply systems; aquifer analysis; surges and water hammer.

441. Highway Operations
Spring. 3(3-0) C E 346 or C E 342.
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. 4(3-2) C E 345.
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.

445. Transportation Planning
Winter. 3(3-0) C E 342 or C E 346.
Urban transportation facilities needs and programs. Design of transportation models for urban highways and public transit including trip generation, trip distribution, mode split and traffic assignment. Transport agencies function and services.

449. Highway Engineering
Spring. 3(2-2) C E 308, C E 347.
Design concepts of roadway 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
(487) Fall. 4(3-2) C E 280.
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.

493. Water and Wastewater Treatment
Spring. 4(4-0) C E 280, C E 421, C E 422 or concurrently, by approval of department.
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.

495. Environmental Health Engineering
Winter. 3(3-0) MPH 200, C E 280.
Epidemiology of communicable disease transmitted by air, water, food and arthropods, engineering measures to control disease spread. Incidence and prevalence rates, well design; cross-connections, disinfection, sanitary inspection; case studies.

499. Civil Engineering Projects
Fall, Winter, Spring, Summer. Variable credits. May be repeated for a maximum of 6 credits. Approval of department.
Original civil engineering problem of specific interest to the student and a faculty member. Student's proposal describing problem required prior to approval.

800. Operations Research Techniques for Civil Engineers
Fall. 3(3-0) Graduate standing.
Elements of deterministic methods of operations research with emphasis on computational techniques and application to civil engineering problems such as structural design, water supply, transportation, and construction management.

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. Prestressed concrete.

807. Model Analysis
Fall. 3(3-0) 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.

808. Finite Element Method
Fall. 4(4-0) Approval of department. Interdepartmental with the departments of Metallurgy, Mechanics and Materials Science and Agricultural Engineering and 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
Winter. 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(3-0) C E 419 or approval of department.
Mechanical properties of soils 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.  

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; gradually and rapidly varied flow; design applications.

824. Fluid Transients  
Spring of odd-numbered years. 4(4-0) C E 428 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; nullitude 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 freeway ramp metering algorithms. Offline and online optimization of traffic signal timing.

827. 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.

828. 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.

829. Traffic Engineering Theory and Control  
Spring. 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 operations and urban transportation modes.

830. Environmental Impacts of Transportation Facility Design Decisions  
Spring. 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.

831. Highway Planning  
Fall. 3(3-0) C E 345 or approval of department.  
Highway inventory, road use studies and programming, analysis of highway costs, economic considerations in location and design.

832. 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.

833. Transportation Models  
Spring. 3(3-0) C E 449.  
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.

834. 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 896 or C E 899.

835. 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 frame, and shells.

836. 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.

837. 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, Pucker's stress function, deformations and bending of shells of revolution and shallow shells.

838. 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.

839. 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.

840. 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 medium.

841. Mass Transit Routing and Scheduling  
Fall of even-numbered years. 3(3-0) C E 549 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.

842. Research  
Fall, Winter, Spring, Summer. Variable credit. Approval of department.

Sanitary Engineering  
S E

843. Physical Chemical Processes of Environmental Engineering  
Fall. 5(3-4) C E 481, C E 483 or concurrently.  
Analysis of physical and chemical processes 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
(566.) Winter. 4(4-0) MPH 300, 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
(565.) Winter. 4(3-3) E C 483, E C 825, S E 802.
Theory and design of water treatment processes. Coagulation and flocculation; softening; sedimentation; filtration; disinfection.

814. Wastewater Treatment Plant Design
(566.) Spring. 4(3-3) E C 370, E C 483, C E 825, S E 804.
Theory and design of wastewater treatment processes. Tanks, screens, sedimentation basins, trickling filters, aeration tanks, digesters.

816. Treatment of Industrial Wastes
(603.) 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 industry.

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

850. Special Problems in Environmental Engineering
Fall, Winter, Spring, Summer. 1 to 6 credits. May reenroll for a maximum of 12 credits in C E 800 and S E 800 combined. Approval of department.
Solution of environmental engineering problems, of limited scope not pertaining to thesis.

899. 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 822.
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. Research
Fall, Winter, Spring, Summer. Variable credit. Approval of department.

COMMUNICATION COM

College of Communication Arts and Sciences
(Names changed effective July 1, 1975. Formerly College of Communication Arts.)

100. Human Communication I
Fall, Winter, Spring, Summer. 3(3-0).
Process and functions of communication. Principles underlying communication behavior. Practice in analyzing communication situations and in speaking and writing.

101. Human Communication II
Fall, Winter, Spring, Summer. 3(3-0) 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 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, 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.

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

315. Organizational Communication
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, Summer. 4(4-0) 326.
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 behavior. Semiotics and general semantics.

350R. Signs and Sign-Behavior II
Fall, Winter, Spring. 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 300.
Interdependence of communication and other societal factors, emphasizing criteria for ethical and social appropriateness.

399. Special Topics in Communication
Fall, Winter, Spring, Summer. 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 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 classroom, 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
Winter, Summer. 4(4-0) ED 327.
Philosophies of curricular and co-curricular programs in communication education. Internship experience in those programs.