

BIOLOGY

Professors: J. L. Dickey, D. R. Helms, R. J. Kosinski, W. M. Surver; *Associate Professors:* R. A. Garcia, K. D. Layfield, C. K. Revis-Wagner, A. D. Smith, S. A. Sparace, J. A. Waldvogel; *Assistant Professors:* M. V. Ruppert; *Senior Lecturer:* V. C. Minor; *Lecturers:* T. Kaisa, S. D. Stocks

BIOL 103, H103 General Biology I 3(3,0) First in a two-semester sequence. Includes an evolutionary approach to cells, cellular activities, genetics, and animal diversity emphasizing the processes of science. Credit toward a degree will be given for BIOL 103 or 110 only.

BIOL 104, H104 General Biology II 3(3,0) Continuation of BIOL 103. Includes an evolutionary approach to human anatomy and physiology, plant diversity, morphology, and physiology and principles of ecology. Credit toward a degree will be given for BIOL 104 or 111 only.

BIOL 105 General Biology Laboratory I 1(0,3) Laboratory to accompany BIOL 103. Emphasizes developing laboratory techniques, becoming familiar with biological instrumentation, and performing investigations and interpreting results in the areas of biochemistry, cell biology, and molecular biology. *Coreq:* BIOL 103.

BIOL 106 General Biology Laboratory II 1(0,3) Laboratory to accompany BIOL 104. Emphasizes developing laboratory techniques, becoming familiar with biological instrumentation, and performing investigations and interpreting results in the areas of organismal structure, physiology, and ecology. *Coreq:* BIOL 104.

BIOL 109 Introduction to Life Science 4(3,3) Survey of topics in botany, zoology, microbiology, and ecology emphasizing comprehension and practical application of life-science concepts to experiments and activities for the elementary school classroom. Enrollment priority will be given to Early Childhood and Elementary Education majors.

BIOL 110, H110 Principles of Biology I 5(4,3) Introductory course designed for students majoring in biological disciplines. Integrates lecture and laboratory and emphasizes a modern, quantitative, and experimental approach to explanations of structure, composition, dynamics, interactions, and evolution of cells and organisms. High school chemistry is recommended. Credit toward a degree will be given for BIOL 110 or 103 only. *Coreq:* CH 101.

BIOL 111, H111 Principles of Biology II 5(4,3) Continuation of BIOL 110, emphasizing the study of plants and animals as functional organisms and the principles of ecology. Credit toward a degree will be given for BIOL 111 or 104 only. *Preq:* BIOL 110.

BIOL 120 Biological Inquiry Laboratory 1(0,3) Required laboratory experience to accompany BIOL 121, 122, 123, or 124. Focuses on the process and outcomes of scientific inquiry. Students employ scientific methodology in a laboratory environment as well as critical analysis of biological problems in a small group context. *Coreq:* BIOL 121, 122, 123, or 124.

BIOL 121 Keys to Human Identity 3(3,0) Introduction to scientific inquiry that emphasizes the biological aspects of human identity, including genetics, development, and the brain. Applications in biotechnology and ethical issues associated with these topics are discussed. Credit toward a degree will be given for only one of BIOL 121, 122, 123, 124.

BIOL 122 Keys to Biodiversity 3(3,0) Introduction to scientific inquiry through analysis of biodiversity. Biological foundations for life are studied, including evolution, ecology, genetics, cells, and molecules. Also includes discussion of ethical issues related to biodiversity. Credit toward a degree will be given for only one of BIOL 121, 122, 123, 124.

BIOL 123 Keys to Human Biology 3(3,0) Introduction to scientific inquiry through human biology. Considers biological processes occurring within humans and human impact on global biological processes. Interrelationships ultimately affecting evolution and diversity are explored. Credit toward a degree will be given for only one of BIOL 121, 122, 123, 124.

BIOL 124 Keys to Reproduction: Cells, Organisms, Populations, Ecosystems 3(3,0) Introduction to scientific inquiry through analysis of the process of reproduction. The ethics of human reproduction and the evolution and ecological impact of population growth and extinction are emphasized. Credit toward a degree will be given for only one of BIOL 121, 122, 123, 124.

BIOL 201 Biotechnology and Society 3(3,0) Introduction to the theories, fields, and applications of biotechnology including the structure and function of genes and their manipulation to improve plant and animal productivity and human health. Individual case studies are examined including social and ethical issues surrounding biotechnology-based research and development. Not open to Genetics majors. *Preq:* BIOL 120 and 121, 122, 123, or 124; or equivalent; or consent of instructor.

BIOL 203 Human Disease and Society 3(3,0) Focuses on the basic biology underlying human disease, how disease is understood, and current methods of prevention and treatment of disease. The economics as well as the social and ethical issues surrounding human disease are a common thread throughout the course. *Preq:* BIOL 104/106; 111; 121, 122, 123, or 124; or consent of instructor.

BIOL 210 Evolution and Creationism 3(3,0) Critical review of the scientific and technological basis for evolutionary theory compared to creationist explanations for the origin and diversity of life. Includes a historical survey of the impact that the evolution/creation debate has had on law, politics, education, and other important aspects of society. *Preq:* BIOL 104/106; 111; 121, 122, 123, or 124; or consent of instructor.

BIOL 220 Biology: Concepts, Issues, and Values 3(3,0) Develops a thorough knowledge of basic biological concepts and issues and explores how these can be incorporated into a system of human values affecting technology, society, and life.

BIOMOLECULAR ENGINEERING

BMOLE 423, 623 Bioseparations 3(3,0) Study of principal methods of separation and purification of bioproducts, such as proteins, amino acids, and pharmaceuticals. Topics include analytical bioseparations, membrane separations, sedimentation, cell disruption, extraction, adsorption, chromatography, precipitation, crystallization, and drying. *Preq:* BIOCH 301, CH E 330, or consent of instructor.

BMOLE 425, 625 Biomolecular Engineering 3(3,0) Introduction to basic principles of biomolecular engineering: the purposeful manipulation of biological molecules and processes applied to problems and issues in the life sciences, biotechnology, and medicine. Topics include carbohydrates, proteins, nucleic acids, and lipids with emphasis on their structure-property-function relations; molecular recognition; biochemical pathway engineering; and cell growth. *Preq:* CH E 230 and 319 or consent of instructor.

BIOSYSTEMS ENGINEERING

Professors: W. H. Allen, *Chair;* D. E. Brune, R. B. Dodd, Y. J. Han, J. C. Hayes; *Associate Professors:* J. P. Chastain, C. M. Drapcho, C. V. Privette, T. H. Walker; *Assistant Professor:* T. O. Owino; *Lecturer:* P. M. Patel

B E 210 Introduction to Biosystems Engineering 2(1,3) Overview of topics and engineering application areas that comprise the Biosystems Engineering profession. Significant emphasis is also given to development of oral and written communication skills needed by the engineering professional, introduction to design methodology, and application of engineering fundamentals to biological systems. *Preq:* ENGR 130, MTHSC 106.

B E 212 Fundamentals of Biosystems Engineering 2(1,3) Introduction to fundamental concepts in biosystems engineering, including mass, energy, and momentum balances; mass, heat, and momentum transfer; biological response to environmental variables, biological materials, biological kinetics, and techniques of measurement and analysis of engineering and biological data. Laboratory includes hand-on exercises, problem solving and computer sessions, and oral presentations. *Preq:* B E 210.

B E 222 Geomeasurements 2(1,3) Fundamentals of land measurement and traverse calculations. Leveling, earthwork, area, and topographic measurements using levels, total stations, and GPS. Application of mapping via GIS. *Preq:* MTHSC 106.

B E H300 Biosystems Engineering Honors Seminar 0(0,1) Introduces undergraduate students to current faculty research. Project ideas are then developed to prepare students in choosing a research topic for the senior honors thesis. Students are required to attend senior honors thesis presentations. To be taken Pass/Fail only. *Preq:* Junior standing in departmental honors program.

- B E H301 Biosystems Engineering Honors Thesis Research 3(0,6)** Honors thesis project proposal, initial research, report, and presentation of biosystems engineering project for completion of junior requirements of the Biosystems Engineering Honors program. *Preq:* B E H300
- B E 312 Biological Kinetics and Reactor Modeling 3(2,3)** Fundamentals of microbial and biochemical kinetics used in analysis and design of biological systems. Topics include mathematical and computer modeling of biological kinetics and systems, estimating model coefficients, and development of microbial kinetic models as basis for batch and continuous reactor design. *Preq:* B E 212, MTHSC 208.
- B E 314 Biosystems Engineering Mechanical Design 3(3,0)** Study of basic mechanical design of biosystems. Includes an introduction to biomechanics and biomaterial properties. Studies applications of machine components and their selection related to specific types of biosystems. Team design project is required. *Preq:* C E 206 or M E 302.
- B E 322 Small Watershed Hydrology and Sedimentology 3(3,0)** Fundamental relationships governing rainfall disposition are used as bases for defining the hydrology of watersheds. Emphasizes application of modeling techniques appropriate for runoff and sediment control. *Preq:* PHYS 122. *Coreq:* C E 321 or CSENV 202.
- B E 370 Practicum 1-3** Preplanned internship with an approved employer involved with biosystems engineering endeavors. A minimum 130 hours of supervised responsibility is required per credit hour. Evaluation is based on activity journal, written/oral report, and an evaluation from the supervisor. May be repeated for a maximum of three credits. To be taken Pass/Fail only. *Preq:* Junior standing and departmental consent.
- B E H400 Biosystems Engineering Honors Thesis 3(0,6)** Individual research projects are conducted under the supervision and guidance of a faculty member. Senior honors thesis is required. *Preq:* B E H300, H301.
- B E (CSENV) 408, 608 Land Treatment of Wastewater and Sludges 3(3,0)** See CSENV 408.
- B E 412, 612 Heat and Mass Transport in Biosystems Engineering 3(3,0)** Fundamentals of heat and mass transport used in engineering design and analysis of biological systems; principles of steady state and transient energy and mass balances including chemical and biological generation terms. *Preq:* B E 312, MTHSC 208. *Coreq:* M E 310.
- B E 414, 614 Biosystems Engineering Unit Operations 3(2,3)** Applies the basic principles of statics, dynamics, and thermodynamics to design of mechanical and electrical systems supporting biological operations and processes. *Preq:* B E 314, M E 310.
- B E 415, H415, 615 Instrumentation and Control for Biosystems Engineers 4(3,3)** Overview of modern instrumentation techniques and digital electronic components and subsystems to integrate them into digital data acquisition and control systems for biosystems. Laboratory use of equipment is emphasized. Topics include characteristics of instruments, signal conditioning, transducer theory and applications, programmable logic controllers, and digital data acquisition and control. *Preq:* E C E 307.
- B E 417, 617 Applied Instrumentation and Control for Biosystems 2(1,3)** Hardware and software implementation of digital data acquisition and control systems for application to agriculture, aquaculture, biotechnology, and other biosystems. Topics include digital electronic circuits and components, microcomputer architecture, interfacing, and programming. *Preq:* B E 415 or consent of instructor.
- B E 421 Engineering Systems for Soil Water Management 2(1,3)** Presents fundamentals of design related to drainage of lands, irrigation, and modification of the microenvironment for optimum productivity. *Preq:* MTHSC 208. *Coreq:* C E 341.
- B E 422, 622 Hydrologic Modeling of Small Watersheds 3(3,0)** Design of structures and development of best management practices for runoff, flood, and sediment control from rural and urban areas, including natural and disturbed watersheds. Topics include modeling of prismatic and non-prismatic channels, culverts, and detention/retention ponds. *Preq:* B E 322 or consent of instructor.
- B E (CH E) 428, 628 Biochemical Engineering 3(3,0)** Use of microorganisms and enzymes for the production of chemical feedstocks, single-cell protein, antibiotics, and other fermentation products. Topics include kinetics and energetics of microbial metabolism, design and analysis of reactors for microbial growth and enzyme-catalyzed reactions, and considerations of scale-up, mass transfer, and sterilization during reactor design. *Preq:* B E 312, MICRO 305; *Coreq:* (for Biosystems Engineering majors) BIOCH 301 or 305; (for Chemical Engineering majors) CH E 330, 450.
- B E 431 Structural Design for Biosystems 2(2,0)** Analysis and design of structures and statically determinant components with emphasis on wood. *Preq:* C E 206 or M E 302.
- B E 435, 635 Applications in Biotechnology Engineering 3(2,3)** Bioengineering principles applied to the expanding fields of agricultural biotechnology, ecotechnology, and biomedical technology. Specific applications include waste treatment and ecological engineering, bioreactor propagation of plant and animal cells and tissues, applied genomics and synthetic seed production, biosensors and biomonitoring, biological implants and materials biocompatibility. *Preq:* B E (CH E) 428.
- B E 438, 638 Bioprocess Engineering Design 3(2,2)** Design and analysis of systems for processing biological materials. Topics include biotechnology, thermodynamics, transport processes, and biological properties related to bioprocess design and computational simulation. Unit operations include basic bioreactor operation, bioseparations, and preservation techniques. *Preq:* B E (CH E) 428.
- B E 440, 640 Renewable Energy Resource Engineering 3(2,2)** Investigation into merging renewable energy resources, including detailed study of solar, wind, and bioenergy alternatives. Also includes principles, technologies, and performance evaluation of components for these technologies and an introduction to tidal, hydro, geothermal, and other energy; energy conservation; cogeneration; financial, economical, and other issues related to alternative energy sources. *Preq:* Science or engineering major, consent of instructor.
- B E 442, 642 Properties and Processing of Biological Products 2(1,3)** Study of engineering properties of biological materials and their uniqueness as design restraints on systems for handling, processing, and preserving biological products. *Preq:* B E 333, C E 341, M E 302, 310.
- B E (EE&S, FOR) 451, H451, 651 Newman Seminar and Lecture Series in Natural Resources Engineering 1(0,2)** Topics dealing with development and protection of land, air, water, and related resources are covered by seminar with instructor and invited lecturers. Current environmental and/or resource conservation issues are addressed. *Preq:* Senior standing, consent of instructor.
- B E 464, 664 Non-Point Source Management in Engineered Ecosystems 3(2,3)** Fundamentals of non-point source pollution including quantification of environmental impact and ecosystem management related to contaminants and nutrients and to planning and design of ecological systems. *Preq:* MICRO 305, Senior standing in engineering, or consent of instructor.
- B E 473 Special Topics in Biosystems Engineering 1-3(1-3,0)** Comprehensive study of special topics not covered in other courses. Emphasizes independent pursuit of detailed investigations. Senior standing and consent of department.
- B E 474 Biosystems Engineering Design/Project Management 2(1,3)** Study of biological systems design using hydrology principles, fluid mechanics, bioprocessing, heat/mass transfer, instrumentation, mechanical unit operations, and structural principles for project design, scheduling, and cost estimation. Topics also include engineering ethics, professional development, written and oral communication, and job skills. Senior portfolios are also developed. *Preq:* B E 314, 412, 415; 428 (Applied Biotechnology Concentration) or 322 (Natural Resources and Environment Concentration).
- B E 475 Biosystems Engineering Capstone Design 2(0,4)** Applications of hydrology, fluid mechanics, bioprocessing, heat/mass transfer, instrumentation, mechanical unit operations, and structural principles in design; project scheduling; cost estimation; ethics; environmental and social impacts; design drawings; and report documentation. *Preq:* B E 474; C E 431 or CH E 230.
- B E (EE&S) 484, 684 Municipal Solid Waste Management 3(3,0)** See EE&S 484.

BUSINESS

BUS 101 Business Foundations 1(1,0) Overview of the business environment. Topics include the economic and legal foundations of business and an introduction to the human resources, marketing, operations, and financial functions of global businesses.

BUS H291 Honors Seminar in International Business 1(1,0) Introduction to the International Business Honors Program presented through a discussion of thesis expectations, study abroad experiences, and seminars given by returning senior International Business Honors students. To be taken Pass/Fail only. *Preq:* Membership in Calhoun Honors College.

BUS H391 International Business Honors Thesis Research 1(1,0) Students work with a Clemson advisor and an international advisor to develop a research topic for the senior thesis. Students work and conduct research while participating in an approved study abroad. To be taken Pass/Fail only. *Preq:* BUS H291.

BUS H392 International Business Honors Thesis Proposal 1(1,0) Students work with a Clemson advisor and an international advisor to complete a proposal for the senior thesis. Students work and conduct research while participating in an approved study abroad. To be taken Pass/Fail only. *Preq:* BUS H391.

BUS H491 International Business Honors Thesis I 3(3,0) Students work with an advisor to conduct literature review and research on a senior thesis topic and prepare presentations and thesis drafts based on this work. *Preq:* BUS H392.

BUS H492 International Business Honors Thesis II 3(3,0) Students work with an advisor to complete a senior thesis. They prepare and present a seminar on the topic for presentation to faculty and other International Business Honors students. *Preq:* BUS H491.

CALHOUN HONORS SEMINAR

C H S H199 Calhoun Scholars Colloquium 3(3,0) Intellectually intensive seminar that engages freshmen honors students in dialogue about the idea of the University. Welcomes students to a community of scholars by providing perspectives on key concepts and tools that organize intellectual inquiry across disciplines. Topics vary. *Preq:* Membership in Calhoun Honors College.

C H S H201 Structures and Society 3(3,0) Interdisciplinary honors seminar that examines selected structures regarded as monuments to artistic creativity and technological genius and the ways that structures affect and are affected by the societies that produce them. *Preq:* Membership in Calhoun Honors College.

C H S H202 Science, Culture, and Human Values 3(3,0) Interdisciplinary honors seminar that unifies natural scientific, social scientific, and humanistic disciplines into a holistic view of the modern world and its future. May be repeated for a maximum of six credits, but only if different topics are covered. *Preq:* Membership in Calhoun Honors College.

C H S H203 Society, Art, and Humanities 3(3,0) Combines readings and methodologies from the social sciences, arts, and humanities to study the interrelationships among the disciplines and their societal effects. Subjects vary. May be repeated for a maximum of six credits, but only if different topics are covered. *Preq:* Membership in Calhoun Honors College.

C H S H204 Honors Study/Travel 1(0,3) Study/travel experience related to a three-credit Calhoun Honors Seminar. May be repeated for a maximum of three credits, but only if different topics are covered. *Preq:* Membership in Calhoun Honors College.

C H S H205 Methods of Interpretation 1(1,0) Seminar to teach students how to interpret documents, works of art, structures, and scholarly materials related to a three-credit Calhoun Honors Seminar. May be repeated for a maximum of three credits, but only if different topics are covered. *Preq:* Membership in Calhoun Honors College.

C H S H206 Controversies in Science and Technology 3(3,0) Interdisciplinary honors seminar that examines social issues related to science and technology, using perspectives from science, the social sciences, and humanities. May be repeated for a maximum six credits, but only if different topics are covered. *Preq:* Membership in Calhoun Honors College.

C H S H209 Border Crossings: Experiences in World Cultures 1-3(1-3,0) Readings and studies that heighten understanding of world cultures and societies. Taken in conjunction with international educational experiences approved by Calhoun Honors College. May be repeated for a maximum of six credits, with a maximum of three credit hours per study abroad experience. *Preq:* Membership in Calhoun Honors College.

C H S H210 Experiencing the Arts 3(2,3) Interdisciplinary exploration of the arts through seminar discussions and attendance at performing and visual arts events on campus. Exploration of arts and aesthetics leading to performance previews, reviews, and experiences of Brooks Center and Lee Gallery events. May be repeated for a maximum of nine credits. *Preq:* Membership in Calhoun Honors College.

C H S H400 Honors Contract 0(0,0) Advanced study and research taken in conjunction with any 300–400-level course. Contract requires prior approval by instructor and Honors Director. To be taken Pass/Fail only. May be repeated once, but only if in conjunction with different course. *Preq:* Membership in Calhoun Honors College.

CAREER AND TECHNOLOGY EDUCATION

Professors: W. L. Havice, W. D. Paige; *Associate Professor:* C. E. Poston; *Lecturer:* H. L. Harrison

CTE 110 Introduction to Career and Technology Education 3(2,3) Examines the philosophy of technology education in the public school system and the philosophy and organization of training and development. Students are given an orientation to the major in Technology and Human Resource Development and an overview of the principles of technology.

CTE 115 Contemporary Technological Problems 3(3,0) Provides students with an understanding of the problems and contributions of technology. Examples are taken from historical accounts and from analyses of contemporary technological intervention both in industrialized and nonindustrialized countries.

CTE 160 Training Programs in Industry 3(3,0) Introduction and first-hand experience in industrial training programs. Emphasis is on observing and participating in actual training situations as well as communications and media usage in industry. *Preq:* CTE 110.

CTE 180 Introduction to Technical Drawing and Computer-Aided Drafting 3(1,6) Introductory drafting course utilizing traditional drafting techniques and computer software to explore technical drawing and orthographic projection through construction of multiview and isometric projections, sectional and auxiliary views, dimensioned working drawings, developments, and intersections. Freehand sketching is a means of problem solving and analysis.

CTE 181 Technical Design 3(1,6) Provides students with the basic procedures involved in the design of a new technology product, including needs identification; functional analysis; functional allocation; resource identification; optimization; and schedule, cost, and performance management. *Preq:* CTE 110, 180 or equivalent; or consent of instructor.

CTE 220 Manufacturing Technology I: Systems 3(2,3) Introduction to management, personnel, and production systems studies through the creation of a corporation. Includes product identification, product research and design, selection of processes, plant design, production systems, and system enhancement. *Preq:* CTE 110 and 180 or consent of instructor.

CTE 221 Exploring Technology 3(3,0) Covers a wide range of technological concepts along with familiar examples of how technology impacts our lives as individuals, a society, and a global community.

CTE 230 Construction Technology I: Materials 3(2,3) Introduction to the commonly used building materials and methods of combining them in present day construction. *Preq:* CTE 110 or consent of instructor.

CTE 240 Power Technology I: Production 3(2,3) Study of power in terms of energy sources and the generation of power. Emphasizes the development of insights and understandings of the scientific and operational principles involved in the production and utilization of power. *Preq:* CTE 110 or consent of instructor.

CTE 250 Electricity 3(2,3) Theory and application of DC and AC fundamentals, including instrumentation, power sources, circuit analysis, motors, construction wiring, and electronic principles and components.

CTE 280 Communications Technology I: Processes and Materials 3(2,3) Topics include graphic communications, photography, computer application and use as a visual communication medium, and audio/video production and application.

- CTE 310 Designing Creative Instruction 3(2,2)**
Provides preservice teachers with opportunities to develop skills in technological literacy, design, inquiry-based instruction, and problem solving using a variety of media, with emphasis on their applications in the elementary curriculum. *Prq:* Junior standing in Early Childhood or Elementary Education or consent of instructor.
- CTE (ED F) 315 Technology Skills for Learning 1(0,2)** See ED F 315.
- CTE 360 Safety 3(3,0)** Study of the relationship of training and safety personnel to the kinds of tasks they are asked to perform. Emphasizes safety knowledge development and techniques which may be used in safety training.
- CTE 370 Motivation and Discipline in Career and Technology Education 3(3,0)** Provides classroom teachers and prospective teachers with knowledge and skills in techniques of student discipline and motivation with application to the technology education settings.
- CTE 371 Management of Career and Technology Education Laboratories 3(2,2)** Management and operation of unit and multiple-activity laboratories, including laboratory design, selection and procurement of tools and equipment, budgeting management, and coordination of activities in laboratory courses.
- CTE 390 Cooperative Experience I 6(0,18)** Full-time work experience in industry. Students are requested to register with the instructor one semester prior to the summer in which they plan to enroll. Offered summer session only.
- CTE 410, 610 Selected Topics 1-3(1-3,0)** Subject areas organized according to program needs. Content is planned cooperatively by the University and the school system or agency requesting the course. May be repeated for a maximum of 18 credits, but only if different topics are covered. *Prq:* Consent of instructor.
- CTE 415, 615 History and Philosophy of Career and Technology Education 3(3,0)** Study of career and technology education programs with the intent of developing a sound individual philosophy. General topics covered are history, local, state, and federal legislation; types of career and technology programs; professional organizations and career guidance.
- CTE 420, 620 Manufacturing II: Computer-Integrated Manufacturing 3(2,3)** Study of computer-integrated manufacturing and its related concepts, including robotics, computer numeric control, electronic pneumatic and sensor systems, programmable logic controllers, and ancillary devices. *Prq:* CTE 220 or consent of instructor.
- CTE 430, 630 Construction Technology II: Practices and Systems 3(2,3)** Study of industrial practices and systems affecting man, materials, and equipment associated with construction industries. Activities are directed toward developing a working knowledge of construction technology and a framework for incorporating this instruction into programs in the public and private sectors. *Prq:* CTE 230.
- CTE 440, 640 Power Technology II: Transmission and Control Systems 3(2,3)** Continuation of CTE 240. Instruction in transmitting and controlling power for utilization in such areas as manufacturing, communications, construction, and transportation. Introduces concepts of automation and robotics to enable the classroom teachers and industry personnel to gain necessary insights into this important area of technology. *Prq:* CTE 240.
- CTE 450 Electronics for Educators 3(1,6)** Principles of electronics as applied in communications and automatic controls involving transistors, integrated circuits, and other electronic devices and materials for the preparation of teachers of industrial arts and vocational-technical electricity and electronics. *Prq:* CTE 250 or equivalent.
- CTE 460, 660 Developing Training Programs for Industry 3(3,0)** Identification, selection, and organization of subject matter for industrial training programs. Emphasizes analysis techniques, session and demonstration planning, written instructional materials development, trainee evaluation, and planning instructional schedules. *Prq:* Senior standing in Workforce Training Concentration or consent of instructor.
- CTE 461 Workplace Safety 3(3,0)** Consideration of safety-related problems in the workplace. Emphasizes OSHA regulations and procedures. *Prq:* CTE 360.
- CTE 465, 665 Conducting and Evaluating Training Programs 3(3,0)** Basic concepts of supervision, administration, and management of training programs. Emphasis is on determining training requirements, planning, directing, and evaluating training programs. *Prq:* CTE 160, 460 or consent of instructor.
- CTE 468, H468, 668 Public Relations 3(3,0)** Emphasizes techniques and methods of effective public and industrial relations which contribute to understanding and cooperation of labor, business, professional, educational, and industrial groups.
- CTE 470, 670 Course Organization and Evaluation 3(3,0)** Problems, techniques, and procedures in the preparation, selection, and organization of subject matter for instructional purposes. Methods, techniques, and preparation of materials used in the evaluation of student achievement in industrial education subjects.
- CTE 471, 671 Teaching Career and Technology Education 3(3,0)** Effective methods for teaching and training in career and technology education. Emphasis is given to class organization, preparation of lesson outlines, and audio-visual aids.
- CTE 472 Advanced Instructional Methods 3(3,0)** Familiarizes students with the various equipment, materials, and techniques associated with the delivery of instruction. Students design, produce, and present materials to meet specific educational objectives. *Prq:* CTE 471 or one year of teaching experience.
- CTE 473, 673 Assessment in Career and Technology Education 3(3,0)** Study of competency testing in career and technology education which includes educational objectives and measurement; construction and use of oral, objective, short answer, matching, essay, and performance tests; and treatment of test data for grade assignments and statistical analysis.
- CTE 477 Directed Teaching 12(0,36)** Supervised observation and teaching in cooperation with selected public schools in which opportunities are provided for securing experience in teaching industrial subjects. *Prq:* CTE 371, 471, 2.0 cumulative grade-point ratio.
- CTE 478 Internship in Career and Technology Education I 6(0,18)** Supervised observation and teaching in cooperation with selected area career centers, high schools, and technical colleges to provide experience in teaching specified subjects. *Prq:* CTE 371, consent of instructor.
- CTE 479 Internship in Career and Technology Education II 6(0,18)** Continuation of CTE 478. *Prq:* CTE 478, consent of instructor.
- CTE (AG ED, ED F) 480, 680 Educational Applications of Microcomputers 3(2,2)** See ED F 480.
- CTE (AG ED, ED F) 482, 682 Advanced Educational Applications of Microcomputers 3(2,2)** See ED F 482.
- CTE 483, 683 Architectural Drafting for Career and Technology Education 3(1,6)** Study of the major aspects of architectural drawing, such as plot, floor, and foundation plans; wall sections; and elevations. *Prq:* CTE 180.
- CTE 484, 684 Communications Technology II: Systems 3(2,2)** Continuation of CTE 280. Includes theory and operation of communications systems: telegraph, telephone, radio, television, satellites, sound/video recorders, lasers, and computers. Instruction on strategies for interpreting this area of technology to trainees and students is emphasized. *Prq:* CTE 280.
- CTE 486, 686 Instructional Media Development 3(1,4)** Basic instructional media development techniques are presented. Students develop material using authoring software such as HyperCard, transparencies using Persuasion and/or PowerPoint, and fully storyboarded, scripted, and edited digital as well as analog video.
- CTE 490 Cooperative Experience II 6(0,18)** Continuation of CTE 390.
- CTE 491 Special Projects 3(3,0)** Students are assigned projects in accordance with their needs and capabilities. Projects are either experimental, theoretical, or developmental and cover subjects not thoroughly covered in other courses. Written project approval is required before registering. *Prq:* Consent of instructor.
- CTE 492, 692 Advanced Projects 1-6** Students gain depth in content by completing projects under the supervision of an instructor in career and technology education. Written approval is required before registering. May be repeated twice for a maximum of six credits. *Prq:* Consent of instructor.

CERAMIC AND MATERIALS ENGINEERING

Professors: D. A. Brosnan, C. W. Cole, M. S. Ellison, B. I. Lee, G. C. Lickfield, H. J. Rack, K. A. Richardson, *Director;* *Associate Professors:* J. M. Ballato, S. H. Foulger, K. Kornev, I. A. Luzinov, E. C. Skaar; *Assistant Professors:* P. Brown, J. Luo; *Visiting Lecturer:* J. L. Grossman

C M E 210 Introduction to Materials Science 3(3,0) Introductory course in materials science designed primarily for engineering students. Studies the relation between the electrical, mechanical, and thermal properties of products and the structure and composition of these products. All levels of structure are considered from gross structures easily visible to the eye through electronic structure of atoms. *Preq:* CH 101, MTHSC 108, or consent of instructor.

C M E 241 Metrics Laboratory 1(0,3) Provides basic knowledge of statistical techniques and testing procedures used to evaluate materials. Includes sampling procedures, calculation of averages, confidence intervals, Weibull statistics, precision and accuracy to enable quality decision making. *Coreq:* C M E 210.

C M E H300 Honors Seminar 1(1,0) Acquaints students enrolled in the Departmental Honors Program with current research issues in the profession. This assists students in preparing a research proposal for the Senior Thesis. To be taken Pass/Fail only. *Preq:* Junior standing, admission to departmental honors program.

C M E 319 Materials Processing I 3(3,0) Introduction into the principles underlying the processing/manufacturing of ceramic, polymeric, and metallic materials. *Coreq:* C M E 210.

C M E 326 Thermodynamics of Materials 3(3,0) Introduction to physical laws that govern the equilibrium products of chemical and thermal reactions. Covers the three laws of thermodynamics, phase equilibria, energy requirements for reactions, material corrosion, and environmental stability. *Preq:* C M E 210, CH 102, MTHSC 108, PHYS 221.

C M E 327 Transport Phenomena 3(3,0) Kinetic aspects of mass, heat, and fluid transport as they relate to the processing and performance of materials. *Coreq:* C M E 326, MTHSC 208.

C M E 328 Phase Diagrams for Materials Processing and Applications 3(3,0) Teaches students to use single component, binary, and ternary phase diagrams to analyze material processing routes and utilization. Considers reaction pathways by which material microstructure evolves and the relationship of reaction pathway to equilibrium phase diagrams. Also considers material interactions/degradation during use. *Preq:* C M E 326.

C M E 342 Structure/Property Laboratory 2(0,6) Provides a basic understanding of how microstructure interrelationships and processes affect the physical properties of materials and how environmental effects modify structure and mechanical behavior of materials. *Preq:* C M E 241.

C M E 361 Processing of Metals and Their Composites 3(3,0) Examines the control of microstructure-property relationships in metallic materials and their composites through development and selection of innovative manufacturing methods. *Coreq:* C M E 327.

C M E H395 Honors Research I 3(0,9) Individual research under the direction of a Ceramic and Materials Engineering faculty member. *Coreq:* C M E 327, 328.

C M E 402, 602 Solid State Materials 3(3,0) Discussion of the properties of solids as related to structure and bonding with emphasis on electronic materials. Band structure theory, electronic, and optical properties are treated. *Preq:* C M E 326, MTHSC 208, PHYS 221.

C M E 407 Senior Capstone Design 3(1,6) Work with industrial partners who have materials-related processes or product problems. Emphasizes interdisciplinary team approach and global perspective of products and problems. Incorporates critical thinking, group effectiveness, and problem solving with materials and processes. Collaborative efforts between industry and student academic teams are employed. *Preq:* C M E 441, I E 384.

C M E 413 Noncrystalline Materials 3(3,0) Study of the fundamentals of the noncrystalline state. Includes cooling kinetics and effects on formation as well as physical properties of noncrystalline substances in metallic, polymeric, and ceramic systems. *Preq:* C M E 326; *Coreq:* C M E 402.

C M E 416, 616 Electrical Properties of Materials 3(3,0) Covers a range of topics dealing with electrical and magnetic materials including metal and polymer conductors, insulators, ceramic and polymer materials for dielectric applications, and ferroelectric, piezoelectric, pyroelectric, and electrooptic materials. Metal and ceramic magnetic materials are also discussed.

C M E 422 Mechanical Behavior of Materials 3(3,0) Covers the microstructural basis of deformation and fracture in ceramic, metallic, and polymeric systems. *Preq:* E M 201, MTHSC 208.

C M E 424, 624 Optical Materials and Their Applications 3(3,0) Introduces the interaction of materials with light. Specific topics include fundamental optical properties, materials synthesis, optical fiber and planar waveguides, and the componentry and systems-level aspects of optical communication systems. *Preq:* C M E 402, 413.

C M E 432 Manufacturing Processes and Systems 3(3,0) Plant layout and design for manufacturing of ceramic products. Emphasizes process control and verification of processing results. Includes adaptation of computers in process simulation/robotics and the use of programmable logic controllers and robotics in processing. *Preq:* C M E 326.

C M E 433 Combustion Systems and Environmental Emissions 3(3,0) Study of the application of burners, burner controls, firing atmospheres, hydrocarbon fuels, and other energy resources to industrial kilns, furnaces, and firing operations. Topics include energy resources, fuel chemistry, combustion analysis, ratio control systems, flow and pressure measurement and control, kiln atmosphere controls, industrial burners, and flames. *Preq:* C M E 326.

C M E 441 Manufacturing Laboratory 1(0,3) Provides students with the understanding of process optimization. Emphasizes the use of complex experimental design schemes to elucidate the interrelationships between processing, microstructural development, and resulting properties. *Preq:* C M E 342.

C M E 445 Practice of Materials Engineering 1(1,0) Students working in groups present and discuss practical, ethical, safety, business, and selected technical topics. Invited speakers discuss various aspects of the engineering world. To be taken Pass/Fail only. *Preq:* C M E 432.

C M E (BIO E) 480, 680 Research Principles and Concepts 1(1,0) See BIO E 480.

C M E 490, H490, 690 Special Topics in Ceramic Engineering 1-3(1-3,0) Study of topics not ordinarily covered in other courses. Taught as the need arises. Typical topics could include current research in a specific area or technological advances. May be repeated for a maximum of six credits, but only if different topics are covered. *Preq:* Consent of instructor.

C M E H495 Honors Research II 3(0,9) Individual research under the direction of a Ceramic and Materials Engineering faculty member. *Preq:* C M E H395.

C M E H497 Honors Thesis 1(1,0) Preparation of honors thesis based on research conducted in C M E H395 and H495. *Preq:* C M E H495.

CHEMICAL ENGINEERING

Professors: C. H. Gooding, J. G. Goodwin, Jr., *Chair;* A. Guiseppi-Elie, S. S. Melsheimer, A. A. Ogale, M. C. Thies; *Associate Professors:* D. A. Bruce, G. M. Harrison, D. E. Hirt, S. M. Husson, S. M. Kilbey II, R. W. Rice; *Assistant Professors:* C. L. Kitchens, A. T. Metters

CH E 130 Chemical Engineering Tools 3(2,2) Tools and methods for analyzing engineering problems with applications in chemical and biochemical processes, including development of process flow diagrams, numerical methods, graphing, and applied statistics. Problem-solving and computer skills are developed in the lecture and laboratory activities. *Preq:* CES 102. *Coreq:* MTHSC 108, PHYS 122.

CH E 199 Creative Inquiry—Chemical and Biomolecular Engineering 1-4(1-4,0) In consultation with and under the direction of a faculty member, students pursue scholarly activities individually or in teams. These creative inquiry projects may be interdisciplinary. Arrangements with mentors must be established prior to registration. May be repeated for a maximum of eight credits.

CH E 211 Introduction to Chemical Engineering 4(3,2) Introduction to fundamental concepts of chemical engineering, including mass and energy balances, PVT relationships for gases and vapors, and elementary phase equilibria; problem-solving and computer skills are developed in lab. *Preq:* CH 102, MTHSC 108, PHYS 122; and CH E 130 or ENGR 130.

- CH E 220 Chemical Engineering Thermodynamics I 3(3,0)** Topics include first and second laws of thermodynamics, ideal gases, PVT properties of real fluids, energy balances with chemical reactions, and thermodynamic properties of real fluids. *Preq:* CH E 211, MTHSC 206.
- CH E 230 Fluids/Heat Transfer 4(3,2)** General principles of chemical engineering and study of fluid flow, fluid transportation, and heat transmission. Special emphasis is placed on theory and its practical application to design. *Preq:* CH E 211. *Coreq:* CH E 220, MTHSC 206.
- CH E 299 Creative Inquiry—Chemical and Biomolecular Engineering 1-4(1-4,0)** In consultation with and under the direction of a faculty member, students pursue scholarly activities individually or in teams. These creative inquiry projects may be interdisciplinary. Arrangements with mentors must be established prior to registration. May be repeated for a maximum of eight credits.
- CH E H300 Honors Seminar 1(1,0)** Acquaints students enrolled in the Departmental Honors Program with current research issues in the profession. This assists the student in preparing a research proposal for the Senior Thesis. To be taken Pass/Fail only. *Preq:* Admission to departmental honors program, Junior standing.
- CH E 307 Unit Operations Laboratory I 3(2,3)** Laboratory work in the unit operations of fluid flow, heat transfer, and evaporation. Stress is on the relation between theory and experimental results and the statistical interpretation of those results and on report preparation and presentation. *Preq:* CH E 220; 230 or 311; E G 209. *Coreq:* EX ST 411 or MTHSC 302.
- CH E 311 Fluid Flow 3(3,0)** Fundamentals of fluid flow and the application of theory to chemical engineering unit operations, such as pumps, compressors, and fluidization. *Preq:* CH E 211, MTHSC 206.
- CH E 312 Heat and Mass Transfer 3(3,0)** Study of the basics of heat transmission and mass transport. Special emphasis is placed on theory and its application to design. *Preq:* CH E 220, 311.
- CH E 319 Engineering Materials 3(3,0)** Introduction to the fundamental properties and behavior of engineering materials emphasizing polymers, metals, ceramics, and composite materials. *Preq:* CH E 211. *Coreq:* CH 223, CH E 220.
- CH E 321 Chemical Engineering Thermodynamics II 3(3,0)** Continuation of CH E 220. Topics include thermodynamics of power cycles and refrigeration/liquefaction, thermodynamic properties of homogeneous mixtures, phase equilibria, and chemical reaction equilibria. *Preq:* CH E 220, MTHSC 208.
- CH E 330 Mass Transfer and Separation Processes 4(3,2)** Study of mass transport fundamentals and application of these fundamentals to separation technologies, with emphasis on gas absorption, stripping, distillation, and liquid-liquid extraction. *Preq:* CH E 230. *Coreq:* CH E 321.
- CH E 344 Chemical Engineering Junior Seminar 1(1,0)** Preparation of junior chemical engineering students for entry into the profession. Timely information on job interviewing skills, career placement and guidance, professional registration, professional behavior and ethics, graduate school, and management of personal finances. Outside speakers are used frequently. To be taken Pass/Fail only. *Preq:* CH E 312, Junior standing in Chemical Engineering.
- CH E 353 Process Dynamics and Control 3(3,0)** Mathematical analysis of the dynamic response of process systems. Basic automatic control theory and design of control systems for process applications. *Preq:* MTHSC 208, CH E 311 or 230. *Coreq:* CH E 330 or 413.
- CH E H395 Honors Research I 3(0,9)** Individual research under the direction of a Chemical Engineering faculty member. *Preq:* CH E H300 or consent of department honors coordinator.
- CH E 399 Creative Inquiry—Chemical and Biomolecular Engineering 1-4(1-4,0)** In consultation with and under the direction of a faculty member, students pursue scholarly activities individually or in teams. These creative inquiry projects may be interdisciplinary. Arrangements with mentors must be established prior to registration. May be repeated for a maximum of eight credits.
- CH E 401, 601 Transport Phenomena 3(3,0)** Mathematical analysis of single and multidimensional steady-state and transient problems in momentum, energy, and mass transfer. Both the similarities and differences in these mechanisms are stressed. *Preq:* CH E 330, MTHSC 208.
- CH E 407 Unit Operations Laboratory II 3(1,6)** Continuation of CH E 307 with experiments primarily on the diffusional operations. Additional lecture material on report writing and general techniques for experimental measurements and analysis of data, including statistical design of experiments. *Preq:* CH E 307, 330.
- CH E 412, 612 Polymer Engineering 3(3,0)** Design-oriented course in synthetic polymers. Topics include reactor design used in polymer production, effect of step versus addition kinetics on reactor design, epoxy curing reactions, polymer solubility, influence of polymerization and processing conditions on polymer crystallinity. *Preq:* CH 224 and 332 or consent of instructor.
- CH E 413 Separation Processes 3(3,0)** Study of gas-liquid and liquid-liquid separation techniques emphasizing gas absorption, distillation, and liquid-liquid extraction. *Preq:* CH 332, CH E 312, 321.
- CH E (B) E 428, 628 Biochemical Engineering 3(3,0)** See B E 428.
- CH E 431 Chemical Process Design I 3(3,0)** Steps in creating a chemical process design from original concept to successful completion and operation. Topics include process layout, equipment selection and sizing, safety and environmental evaluation, engineering economics, simulation, evaluation of alternatives, and optimization. *Preq:* CH E 307, 321, 330. *Coreq:* CH E 450.
- CH E 432 Process Development, Design, and Optimization of Chemical Engineering Systems II 5(1,12)** Continuation of CH E 431. Principles of process development, design, and optimization are applied in a comprehensive problem carried from a general statement of the problem to detailed design and economic evaluations. *Preq:* CH E 321, 353, 407, 413, and 450 or consent of department chair.
- CH E 433 Process Design II 3(1,6)** Continuation of CH E 431. Principles of process development, design, and optimization are applied in a comprehensive problem carried from a general statement of the problem to detailed design and economic evaluations. *Preq:* CH E 330, 407, 431, 450.
- CH E 443 Chemical Engineering Senior Seminar I 1(1,0)** Preparation of senior chemical engineering students for entry into the profession. Timely information on job interviewing skills, career placement and guidance, professional registration, professional behavior and ethics, and management of personal finances. Outside speakers are used frequently. To be taken Pass/Fail only. *Preq:* CH E 330, Senior standing in Chemical Engineering. *Coreq:* CH E 431.
- CH E 444 Chemical Engineering Senior Seminar II 1(1,0)** Working in groups, students present and discuss topics related to professional practice, ethics, business, industrial safety, the environment, and selected technical subjects of interest to society. To be taken Pass/Fail only. *Preq:* CH E 344 or 443. *Coreq:* CH E 432.
- CH E 445 Selected Topics in Chemical Engineering 3(3,0)** Topics not covered in other courses, emphasizing current literature, research, and practice of chemical engineering. Topics vary from year to year. May be repeated, but only if different topics are covered. *Preq:* Consent of instructor.
- CH E 450, 650 Chemical Reaction Engineering 3(3,0)** Review of kinetics of chemical reactions and an introduction to the analysis and design of chemical reactors. Topics include homogeneous and heterogeneous reactions, batch and continuous flow reaction systems, catalysis, and design of industrial reactors. *Preq:* CH E 330, 321, CH 332.
- CH E 491, H491 Special Projects in Chemical Engineering 1-3(1-3,0)** Topics requested by students or offered by faculty as the need arises. Topics may include review of current research in an area, technological advances, and national engineering goals. May be repeated for a maximum of six credits, but only if different topics are covered.
- CH E H495 Honors Research II 3(0,9)** Individual research under the direction of a chemical engineering faculty member. *Preq:* CH E H395.
- CH E H497 Honors Thesis 1(1,0)** Preparation of honors thesis based on research conducted in CH E H395 and H495. *Preq:* CH E H495.
- CH E 499 Creative Inquiry—Chemical and Biomolecular Engineering 1-4(1-4,0)** In consultation with and under the direction of a faculty member, students pursue scholarly activities individually or in teams. These creative inquiry projects may be interdisciplinary. Arrangements with mentors must be established prior to registration. May be repeated for a maximum of eight credits.

CHEMISTRY

Professors: M. M. Cooper, S. E. Creager, D. D. DesMarteau, R. K. Dieter, L. A. Echegoyen, S.-J. Hwu, A. L. Kholodenko, J. W. Kolis, R. K. Marcus, W. T. Pennington, Jr., D. W. Smith, Jr., Y.-P. Sun; *Associate Professors:* J. R. Appling, D. P. Arya, G. D. Chumanov, D. Perahia, S. J. Stuart; *Assistant Professors:* G. Bhattacharrya, J. Brumaghim, K. A. Christensen, B. N. Dominy, J. D. McNeill, R. C. Smith; *Lecturers:* K. A. Creager, L. E. Echegoyen, S. R. Ellenberger, J. G. Kaup, A. Kitaygorodsky, S. O'Connor, S. J. Schvaneveldt, D. F. D. Taylor, R. T. Watson, D. G. VanDerveer; *Visiting Assistant Professor:* M. L. Doerr; *Visiting Instructor:* B. S. Lewis

CH 101, H101 General Chemistry 4(3,3) Introduction to the elementary concepts of chemistry through classroom and laboratory experience. Emphasizes chemical reactions and the use of symbolic representation, the mole concept and its applications and molecular structure. Credit toward a degree will be given for only one of CH 101 and 105. *Preq or Coreq:* CMPT score of 3 or higher; or MTHSC 101, 102, 103, or 105.

CH 102, H102 General Chemistry 4(3,3) Continuation of CH 101, treating solutions, rates of reactions, chemical equilibrium, electrochemistry, chemistry of selected elements, and an introduction to organic chemistry. Credit toward a degree will be given for only one of CH 102 or 106. *Preq:* CH 101 with a C or better.

CH 105 Chemistry in Context I 4(3,3) The chemistry of societal issues including air quality, global warming, acid rain, and alternative energy sources is discussed in the context of their impact on society. May not be taken as a prerequisite for organic chemistry. Credit toward a degree will be given for only one of CH 101 or 105.

CH 106 Chemistry in Context II 4(3,3) Continuation of CH 105. Topics include the chemistry of nuclear energy, new energy sources, nutrition, medicines, new materials, and genetic engineering. May not be taken as a prerequisite for organic chemistry. Credit toward a degree will be given for only one of CH 102 or 106. *Preq:* CH 101 or 105.

CH 141 Chemistry Orientation 1(1,0) Lectures, discussions, and demonstrations devoted to health and safety in chemistry laboratories; use of the chemical literature; and career planning. *Preq:* Concurrent enrollment in CH 101.

CH 152 Chemistry Communication I 2(2,0) Methods for scientific communication including oral, written, and electronic formats. Service-learning projects engage participants with community needs pertaining to chemistry issues.

CH 199 Creative Inquiry—Chemistry I 1-4(1-4,0) In consultation with and under the direction of a faculty member, students pursue scholarly activities individually or in teams. These creative inquiry projects may be interdisciplinary. Arrangements with mentors must be established prior to registration. May be repeated for a maximum of eight credits.

CH 201 Survey of Organic Chemistry 4(3,3) Introduction to organic chemistry emphasizing nomenclature, classes of organic compounds, and chemistry of functional groups. For students needing a one-semester course in organic chemistry. Credit toward a degree will be given for only one of CH 201 or 223. *Preq:* CH 102 or consent of instructor.

CH 205 Introduction to Inorganic Chemistry 3(3,0) One semester treatment which emphasizes the properties and reactions of the more common chemical elements. *Preq:* CH 102.

CH 206 Inorganic Chemistry Laboratory 1(0,3) Introduction to laboratory synthesis and characterization of inorganic compounds. Laboratory sessions consist of a set of six landmark inorganic experiments for which the original authors have been awarded Nobel prizes. *Coreq:* CH 102, 205.

CH 223 Organic Chemistry 3(3,0) Introductory course in the principles of organic chemistry and the derivation of these principles from a study of the properties, preparations, and interrelationships of the important classes of organic compounds. Credit toward a degree will be given for only one of CH 201 or 223. *Preq:* CH 102 or consent of instructor.

CH 224 Organic Chemistry 3(3,0) Continuation of CH 223. *Preq:* CH 223.

CH 227 Organic Chemistry Laboratory 1(0,3) Synthesis and properties of typical examples of the classes of organic compounds. Credit toward a degree will be given for only one of CH 227 or 229. *Preq:* CH 223 or concurrent enrollment.

CH 228 Organic Chemistry Laboratory 1(0,3) Continuation of CH 227. *Preq:* CH 224 (or concurrent enrollment) and 227.

CH 229 Organic Chemistry Laboratory 1(0,3) One-semester laboratory for Chemical Engineering students. Credit toward a degree will be given for only one of CH 227 or 229. *Preq:* CH 223.

CH 299 Creative Inquiry—Chemistry II 1-4(1-4,0) In consultation with and under the direction of a faculty member, students pursue scholarly activities individually or in teams. These creative inquiry projects may be interdisciplinary. Arrangements with mentors must be established prior to registration. May be repeated for a maximum of eight credits.

CH 313 Quantitative Analysis 3(3,0) Fundamental principles of volumetric, gravimetric, and certain elementary instrumental chemical analyses. *Preq:* Concurrent enrollment for credit in CH 315 or 317.

CH 315 Quantitative Analysis Laboratory 2(0,6) Laboratory techniques of volumetric, gravimetric, and elementary instrumental chemical analyses. Credit toward a degree will be given for only one of CH 315 or 317. *Coreq:* Concurrent enrollment for credit in CH 313.

CH 317 Quantitative Analysis Laboratory 1(0,3) Standard techniques of analytical chemistry—gravimetric, volumetric, and instrumental. Credit toward a degree will be given for only one of CH 315 or 317. *Coreq:* Concurrent enrollment for credit in CH 313.

CH 330 Introduction to Physical Chemistry 3(3,0) One-semester treatment of physical chemistry emphasizing topics that are especially useful in the life sciences, agriculture, and medicine: chemical thermodynamics, equilibrium, solutions, kinetics, electrochemistry, macromolecules, and surface phenomena. Credit toward a degree will be given for only one of CH 330 or 331. *Preq:* MTHSC 106.

CH 331 Physical Chemistry 3(3,0) Includes the gaseous state, thermodynamics, chemical equilibria, and atomic and molecular structure, from both experimental and theoretical points of view. Credit toward a degree will be given for only one of CH 330 or 331. *Preq:* MTHSC 206, PHYS 221.

CH 332, H332 Physical Chemistry 3(3,0) Continuation of CH 331, including chemical kinetics, liquid and solid state, phase equilibria, solutions, electrochemistry and surfaces. *Preq:* CH 331 or consent of instructor.

CH 339 Physical Chemistry Laboratory 1(0,3) Experiments are selected to be of maximum value to Chemistry and Chemical Engineering majors. *Coreq:* CH 331 or CH E 220.

CH 340 Physical Chemistry Laboratory 1(0,3) Continuation of CH 339. *Preq:* Concurrent enrollment in CH 332.

CH 399 Creative Inquiry—Chemistry III 1-4(1-4,0) In consultation with and under the direction of a faculty member, students pursue scholarly activities individually or in teams. These creative inquiry projects may be interdisciplinary. Arrangements with mentors must be established prior to registration. May be repeated for a maximum of eight credits.

CH 400 Selected Topics in Chemistry 1-3(1-3,0) Comprehensive study of topics of current interest in chemistry. May be repeated for a maximum of twelve credits, but only if different topics are covered.

CH 402, H402, 602 Inorganic Chemistry 3(3,0) Basic principles of inorganic chemistry are discussed with special emphasis on atomic structure, chemical bonding, solid state, coordination chemistry, organometallic chemistry, and acid-base theories. The chemistry of certain selected elements is treated. *Preq:* CH 331, 332.

CH 403 Advanced Synthetic Techniques 2(0,6) Introduction to advanced laboratory techniques in synthesis and characterization of inorganic and organic compounds. Laboratory sessions consist of a set of eight experiments in modern fields of chemistry, including superconductivity, buckminsterfullerene, bioinorganic chemistry, medicinal chemistry, asymmetric synthesis, and polymer chemistry. *Preq:* CH 227, 228, 402, or consent of instructor.

CH 404, H404, 604 Bioinorganic Chemistry 3(3,0) Covers fundamentals of bioinorganic chemistry with review of necessary inorganic and biochemical concepts. Topics include metal uptake, transport, and storage in biological systems; functions of metals in proteins; metal ion interactions with nucleic acids; physical methods used in bioinorganic chemistry; heavy element toxicity, radiopharmaceuticals and other metallodrugs. *Preq:* BIOCH 301 or CH 205.

- CH 411, 611 Instrumental Analysis 3(3,0)** Principles of operation and application of modern chemical instrumentation in the field of analytical chemistry. Topics include basic electronics, statistics, optical, mass, magnetic resonance, electron and x-ray spectroscopies, radiochemistry, and separation science. *Preq:* CH 331, 332.
- CH 412 Instrumental Analysis Laboratory 2(0,5)** Reinforces principles of chemical instrumentation described in CH 411 by practical, hands-on experience. Aspects of sample preparation, standardization, data acquisition and interpretation, and report formulation procedures common in chemical analyses are considered for a range of modern instrumental methods. *Coreq:* CH 411.
- CH 413, H413 Chemistry of Aqueous Systems 3(3,0)** Study of chemical equilibria in aqueous systems, especially natural waters; acids and bases, dissolved CO₂, precipitation and dissolution, oxidation-reduction, adsorption, etc. *Preq:* CH 102 or 106.
- CH 414, 614 Bioanalytical Chemistry 3(3,0)** Survey of selected areas of importance in bioanalytical chemistry. Fundamental principles, advanced topics, and applications of analytical measurements of biomolecules, bioassays, immunoassays, separations, mass spectrometry, method validation, macromolecular crystallography, microscopy, and imaging. *Preq:* CH 313, 411, or consent of instructor.
- CH 421, H421, 621 Advanced Organic Chemistry 3(3,0)** Survey of modern organic chemistry emphasizing synthesis and mechanisms. *Preq:* CH 224, 332, or equivalent.
- CH 425, 625 Medicinal Chemistry 3(3,0)** Survey of the pharmaceutical drug discovery process. Covers discovery of candidate compounds, bioassay methods, and associated regulatory and commercial issues. Case studies are selected from the current literature. *Preq:* CH 224 or equivalent or consent of instructor.
- CH 427, H427, 627 Organic Spectroscopy 3(2,3)** Survey of modern spectroscopic techniques used in the determination of molecular structure. Emphasizes the interpretation of spectra: nuclear magnetic resonance, ultraviolet, infrared, mass spectroscopy, optical rotatory dispersion, and circular dichroism. *Preq:* One year each of organic chemistry and physical chemistry.
- CH 435, H435, 635 Atomic and Molecular Structure 3(3,0)** Introduction to quantum theory and its application to atomic and molecular systems. Topics include harmonic oscillator, hydrogen atom, atomic and molecular orbital methods, vector model of the atom, atomic spectroscopy, and molecular spectroscopy. *Preq:* CH 332 or consent of instructor.
- CH 443, H443 Research Problems 1-6(0,3-18)** Original investigation of an assigned problem in a fundamental branch of chemistry. Work must be carried out under the supervision of a member of the staff. May be repeated for a maximum of six credits. *Preq:* Senior standing in chemistry or consent of instructor.
- CH 444, H444 Research Problems 1-6(0,3-18)** Continuation of CH 443. Original investigation of an assigned problem in a fundamental branch of chemistry. Work must be carried out under the supervision of a member of the staff. May be repeated for a maximum of six credits. *Preq:* Senior standing in chemistry or consent of instructor.
- CH 450 Chemistry Capstone 3(1,6)** Students undertake capstone projects in a team format. Projects necessitate the use of electronic and print resources, demonstrate expertise with a specific instrument or experimental technique, require strong collaboration within a team setting, and produce a peer-reviewed oral and written report. *Preq:* Senior standing or consent of instructor.
- CH 451, 651 Frontiers in Polymer Chemistry 3(3,0)** Survey of selected areas of current research in polymer science with particular emphasis on polymer synthesis. Although a text is required for review and reference, course is primarily literature based and focused on areas of high impact to multidisciplinary technology. *Preq:* CH 223, 224, PFC 415 or consent of instructor.
- CH 452 Chemistry Communication II 1(1,0)** Methods for scientific communication including oral, written, and electronic formats. Student presentations focus on current chemical literature topics pertinent to their CH 443/444 undergraduate research or results of that work are appropriate. *Preq:* CH 152.
- CH 471, 671 Teaching Chemistry 3(3,0)** Study of topics in chemistry addressed in the context of constructivist methodologies. Also considers laboratory work and management, laboratory safety, and the use of technology in the chemistry classroom. *Preq:* 300-level chemistry course or high school teaching experience or consent of instructor.
- CH 499 Creative Inquiry—Chemistry IV 1-4(1-4,0)** In consultation with and under the direction of a faculty member, students pursue scholarly activities individually or in teams. These creative inquiry projects may be interdisciplinary. Arrangements with mentors must be established prior to registration. May be repeated for a maximum of eight credits.

CHINESE

Associate Professors: Y. An, Y. Zhang; *Lecturer:* S. Chen

- CHIN 101 Elementary Chinese 4(3,1)** Introductory course stressing speaking, listening, and writing. Attention is given to the sound system of Chinese to enable students to distinguish the four tones and to develop basic communication skills. Participation in cultural activities is encouraged.
- CHIN 102 Elementary Chinese 4(3,1)** Continuation of CHIN 101. *Preq:* CHIN 101 or consent of instructor.
- CHIN 201 Intermediate Chinese 3(3,1)** Intermediate course with more emphasis on communication skills and structure. Reading and writing practice without phonetic aids; oral practice in and outside the class, paying special attention to idiomatic usage; introduction to cultural perspectives through readings and cultural activities. *Preq:* CHIN 102 or consent of instructor.
- CHIN 202 Intermediate Chinese 3(3,1)** Continuation of CHIN 201. *Preq:* CHIN 201 or consent of instructor.
- CHIN 203 Chinese Reading and Composition I 4(3,1)** Designed for students who already speak Chinese but cannot read and write it well. Covers grammatical points of first-year Chinese with special attention to reading and composition. *Preq:* Consent of instructor.
- CHIN 204 Chinese Reading and Composition II 4(3,1)** Continuation of CHIN 203. Covers all grammatical points of regular second-year Chinese. Through reading and discussion of materials regarding Chinese linguistics, history, literature, and philosophy, students improve their language skills and acquire a basic knowledge of Chinese culture. *Preq:* CHIN 203 or consent of instructor.
- CHIN 297 Creative Inquiry—Chinese 1-4(1-4,0)** In consultation with and under the direction of a faculty member, students pursue scholarly activities individually or in teams. Arrangements with faculty members must be established prior to registration.
- CHIN 305 Chinese Conversation and Composition I 3(3,0)** Practice in the spoken language emphasizing vocabulary, word-combinations, pronunciation, and comprehension. Learning practical language skills and intercultural communication by studying various topics. *Preq:* CHIN 202, 204, or consent of department chair.
- CHIN 306 Chinese Conversation and Composition II 3(3,0)** Continuation of CHIN 305. More practice in the spoken language emphasizing vocabulary, word combinations, pronunciation, and comprehension. Learning practical language skills and intercultural communication by studying various topics. *Preq:* CHIN 305 or consent of department chair.
- CHIN (PHIL) 312 Philosophy in Ancient China 3(3,0)** See PHIL 312.
- CHIN (PHIL) 313 Philosophy in Modern China 3(3,0)** See PHIL 313.
- CHIN 316 Chinese for International Trade I 3(3,0)** Study of spoken and written Chinese common to the Chinese-speaking business communities emphasizing business practices and writing/translating business letters and professional documents. Cross-cultural references are provided for comparative analyses of American and Chinese business behavior. Classes are conducted in Chinese. *Preq:* CHIN 202, 305 (or concurrent enrollment) or consent of department chair.
- CHIN 397 Creative Inquiry—Chinese 1-4(1-4,0)** Students focus on a special research area under the guidance of a faculty member. After acquiring the requisite background, students formulate hypotheses for a group project, develop a critical framework, and initiate research on a specific topic.
- CHIN 398 Directed Reading 3(3,0)** Directed readings in Chinese literature, language, society, and culture. Taught in Chinese. May be repeated for a maximum of six credits. *Preq:* Consent of department chair.

CHIN 401 Pre-Modern Chinese Literature in Translation 3(3,0) Chinese literature from 8th century B.C.E. to 19th century C.E. including poetry, prose, drama, fiction, and literary criticism. All readings and discussions are in English.

CHIN 411 Studies in the Chinese Language I: Literature 3(3,0) Advanced training in the spoken and written language through readings in contemporary literature emphasizing vocabulary, syntax, and stylistics. All readings and discussions are in Chinese. *Preq:* CHIN 306 or consent of instructor.

CHIN 412 Studies in the Chinese Language II: Social Issues 3(3,0) In-depth study of terminology and syntax for specific subject areas in contemporary social issues. All readings and discussions are in Chinese. *Preq:* CHIN 306 or consent of instructor.

CHIN 416 Chinese for International Trade II 3(3,0) Study of language, concepts, and the environment of Chinese-speaking markets of the world. Considers sociocultural, political, and economic issues relevant to the Chinese-speaking business world and the ramifications of these issues in global marketing. Classes are conducted in Chinese. *Preq:* CHIN 316 or consent of department chair.

CHIN (ANTH) 418 Chinese Culture and Society 3(3,0) Examines basic cultural values and the patterns of Chinese social life. Focuses on Chinese social organization and interpersonal dynamics, including the family system, gender identities, social exchanges and networks. All readings and discussions are in English. May not be used to satisfy general foreign language requirements.

CHIN 497 Creative Inquiry—Chinese 1-4(1-4,0) Continuation of research initiated in CHIN 397. Students complete their projects and disseminate their research results. *Preq:* CHIN 397 or consent of instructor.

CHIN 498 Independent Study 1-3(1-3,0) Supervised study and research on selected topics in Chinese studies. May be repeated for a maximum of six credits. *Preq:* Junior standing and consent of department chair.

CHIN 499 Selected Topics in Chinese Culture 3(3,0) Examination of various social and cultural topics including art and literature, philosophical and religious traditions, health and healing, and folk and popular cultures. May be repeated for a maximum of six credits, but only if different topics are covered. Readings and discussions are in English. May not be used to satisfy general foreign language requirements.

CITY AND REGIONAL PLANNING

Professors: J. B. London, M. Lauria, D. J. Nadenicek, *Chair;* B. C. Nocks; *Associate Professors:* M. G. Cunningham, J. T. Farris, S. L. Sperry; *Visiting Assistant Professor:* C. A. Schively; *Lecturer:* R. W. Bainbridge; *Adjunct Professor:* G. A. Vander Mey

C R P 401, 601 Introduction to City and Regional Planning 3(3,0) Introduces students from other disciplines to city and regional planning. Spatial and nonspatial areas of the discipline are explored through a wide ranging lecture/seminar program. *Preq:* Consent of instructor.

C R P 402, 602 Human Settlement 3(3,0) Overview of forces and trends affecting community growth and change—historical, ecological, economic, demographic, design, and development—pertaining to human settlement patterns and their interrelationship in the urbanization process, especially at the national, regional, townscape, and neighborhood scale. Team-taught from various perspectives. Intended as a foundation core course for Master's in Real Estate Development, City and Regional Planning, and Landscape Architecture. *Preq:* Consent of instructor.

C R P 403, 603 Seminar on Planning Communication 3(3,0) In-depth analysis of methods to communicate planning and policy decisions effectively. Familiarizes students with the various communication skills needed by planners, policy makers, and other professionals to become successful practitioners. *Preq:* Consent of instructor.

C R P (C E) 412, 612 Urban Transportation Planning 3(3,0) See C E 412.

C R P 434, 634 Geographic Information Systems for Landscape Planning 3(1,6) Develops competence in geographic information systems technology and its application to various spatial analysis problems in landscape planning. Introduces basic principles of GIS and their use in spatial analysis and information management. Topics include database development and management, spatial analysis techniques, cartography, critical review of GIS applications, and hands-on projects.

CIVIL ENGINEERING

Professors: S. N. Amirkhaniyan, N. M. Aziz, *Chair;* L. C. Bell, J. L. Burati, C. H. Juang, R. F. Nowack, S. D. Schiff, P. R. Sparks; *Associate Professors:* R. D. Andrus, W. E. Back, W. A. Sarasua; *Assistant Professors:* M. A. Chowdhury, P. J. Fortney, A. A. Khan, B. G. Nielson, J. H. Ogle, B. J. Putman, P. R. Rangaraju; *Lecturers:* S. G. Brandenburg, S. F. Csernak, N. B. Kaye

C E 204 Civil Engineering and Society 3(2,2) Study of the history and societal impact of major civil engineering projects such as bridges, buildings, dams, tunnels, water supply systems, and transportation systems. Projects are examined in the light of modern concerns for safety, ethics, and their economic and environmental impacts. *Preq:* Sophomore standing or consent of instructor.

C E 206 Structural Mechanics 4(3,3) Builds on statics to develop relationships between external loads on structural elements of civil engineering interest and the resulting internal loads and deformations. Students are exposed to the development of stress and deformation formulas and the identification and use of significant mechanical properties of civil engineering materials. *Preq:* C E 208 or E M 201. *Coreq:* C E 253 or ENGR 130.

C E 208 Civil Engineering Dynamics 2(2,0) Study of kinetics and kinematics of particles and rigid bodies, work and energy, impact and momentum. *Preq:* C E 203 or E M 201 and PHYS 122. *Coreq:* MTHSC 206

C E 251 Analysis Techniques in Civil Engineering 3(2,3) Solution to civil engineering problems using the techniques of dimensional analysis, data analysis, and numerical analyses. The latter includes introduction to FORTRAN programming, simulation analysis, and the numerical solution of systems of linear algebraic equations. *Preq:* ENGR 120. *Coreq:* MTHSC 206.

C E 253 Civil Engineering Measurements 2(3,0) Principles and methods for measurement of loads, load effects, environmental variables, and performance of civil engineering systems. Classes integrate lectures and hands-on applications. Exercises provide students an introduction to sensors, basic electrical circuits, data acquisition systems, and data analysis methods used in civil engineering.

C E 255 Geomatics 3(2,3) Spatial data collection methods including surveying, digital photogrammetry and remote sensing, and global positioning systems. Methods and technologies used to manage, manipulate, and analyze spatial and associated attribute data including geographic information systems. *Coreq:* E G 209.

C E 301 Structural Analysis 3(3,0) Calculation of design loads for buildings and other structures. Use of classical analysis techniques to determine support reactions, internal member forces, and structural displacements of statically determinate and indeterminate structural systems. *Preq:* C E 206 or consent of instructor.

C E 311 Transportation Engineering Planning and Design 3(3,0) Covers planning, design, and operation of transportation facilities including highways and airports. Includes economic, safety, and environmental considerations. Public transit systems are covered. *Preq:* C E 255, EX ST 301.

C E 321 Geotechnical Engineering 4(3,3) Mechanical and physical properties of soils and their relation to soil action in problems of engineering, such as classification, permeability, shearing strength, and consolidation; design of embankments and retaining walls with geotextiles. *Preq:* C E 206; C E 253 or ENGR 130.

C E 331 Construction Engineering and Management 3(3,0) Considers construction contracts, technical specifications, cost estimating, project scheduling, cost control, materials management, quality control, and quality assurance. *Preq:* Junior standing.

- C E 341 Introduction to Fluid Mechanics 4(3,3)** Introduction to fluid mechanics, including hydrostatics and fluid flow. Includes principles of mass, momentum, and energy conservation. Other topics include conduit flow, pump systems, and open channel flow. Laboratory experiments familiarize students with laboratory techniques and instrumentation. The Effective Technical Communications Laboratory is used to prepare a presentation for a lab assignment. *Coreq:* C E 208 or E M 202.
- C E 342 Applied Hydraulics and Hydrology 3(3,0)** Study of hydrologic cycle, including precipitation, evapotranspiration, infiltration, and runoff. Includes hydrograph analysis, gradually varied flow in open channel flow, design of stable channels, flood routing, groundwater hydraulics, flood frequency analysis, and hydrologic design. *Preq:* C E 208 or E M 202; C E 341.
- C E 351 Civil Engineering Materials 4(3,3)** Introduces students to material science and basic properties of construction materials such as aggregate, Portland cement, asphalt cement, concrete, steel, ceramics, wood, and fibers. Experiments in lab and field trips to nearby plants are required. Oral and written communication skills are an integral part of this course. *Preq:* C E 253 or ENGR 130; *Coreq:* EX ST 301 or MTHSC 302.
- C E 352 Economic Evaluation of Projects 2(2,0)** Comparison of design alternatives based on engineering economic analysis. Introduction of present worth, annual cost, rate of return, and benefit-cost ratio methods. Use of depreciation and taxation in project analysis.
- C E 353 Professional Seminar 1(1,0)** Discusses various professional topics related to skills and techniques for evaluating career opportunities, seeking and obtaining civil engineering employment, career development, professional registration, professional ethics, and other factors necessary for achieving success in a professional career. Enables students to make better decisions that will help them succeed in their careers. *Preq:* Junior standing.
- C E H387 Junior Honors Project 1-3** Studies or laboratory investigations on special topics in the civil engineering field which are of interest to individual students and faculty members. Arranged on a project basis for a maximum of individual student effort under faculty guidance. May be repeated for a maximum of three credits. *Preq:* Junior standing in Civil Engineering Senior Departmental Honors Program.
- C E H388 Honors Research Topics 1(0,2)** Survey of ongoing research in the Civil Engineering Department to identify potential research topics for further individual study. *Preq:* Junior standing in Civil Engineering Senior Departmental Honors Program.
- C E H389 Honors Research Skills 1(1,0)** Research problem selection, research tools, research reports organization. *Preq:* C E H388.
- C E 401, 601 Indeterminate and Matrix Structural Analysis 3(3,0)** Analysis of indeterminate structures using moment distribution, energy methods such as virtual work and Castigliano's Theorem and the matrix formulation of the direct stiffness method. *Preq:* C E 301 or consent of instructor.
- C E 402 Reinforced Concrete Design 3(3,0)** Design of reinforced concrete beams, slabs, columns, and footings using ultimate strength design. Includes an introduction to working stress design methods. *Preq:* C E 301 or consent of instructor.
- C E 404, 604 Masonry Structural Design 3(3,0)** Introduction to design of structural elements for masonry buildings, including lintels, walls, shear walls, columns, pilasters, and retaining walls. Reinforced and unreinforced elements of concrete or clay masonry are designed by allowable stress and strength design methods. Includes an introduction to construction techniques, materials, and terminology used in masonry. *Preq:* C E 402 or consent of instructor.
- C E 406 Structural Steel Design 3(3,0)** Introduction to the design of structural elements found in steel buildings, in particular the design of steel tension members, beams, columns, beam-columns, and connections. Additional topics include composite members and plate-girders. Emphasizes the AISC-LRFD Specifications for steel design, though reference is made to the ASD Specification with comparisons made where appropriate. *Preq:* C E 301 or consent of instructor.
- C E 407, 607 Wood Design 3(3,0)** Introduction to wood design and engineering; properties of wood and wood-based materials; design of beams, columns, walls, roofs, panel systems, and connections. *Preq:* C E 402 or 406, or consent of instructor.
- C E 408, 608 Structural Loads and Systems 3(3,0)** In-depth discussion of minimum design loads and load combinations. Includes overview of various steel and concrete systems. Discusses practical selection and design issues and design of proprietary building materials and components such as steel joists, diaphragms, engineered wood products, etc. *Preq:* C E 206, 301.
- C E 410, 610 Traffic Engineering: Operations 3(3,0)** Basic characteristics of motor-vehicle traffic, highway capacity, applications of traffic control devices, traffic design of parking facilities, engineering studies, traffic safety, traffic laws and ordinances, and public relations. *Preq:* C E 311 or consent of instructor.
- C E 411, 611 Roadway Geometric Design 3(2,3)** Geometric design of roadways, at-grade intersections, and interchanges in accordance with conditions imposed by driver ability, vehicle performance, safety, and economics. *Preq:* C E 311 or consent of instructor.
- C E (C R P) 412, 612 Urban Transportation Planning 3(3,0)** Consideration of urban travel characteristics, characteristics of transportation systems, transportation and land-use studies, trip distribution and trip assignment models, city patterns and subdivision layout. *Preq:* C E 311 or consent of instructor.
- C E 421, 621 Geotechnical Engineering Design 3(3,0)** Study of the relationship of local geology to soil formations, groundwater, planning of site investigation, sampling procedures, determination of design parameters, foundation design, and settlement analysis. *Preq:* C E 321 or consent of instructor.
- C E 424, 624 Earth Slopes and Retaining Structures 3(3,0)** Considers the principles of geology, groundwater and seepage, soil strength, slope stability, and lateral earth pressure and their application to the design of excavations, earth fills, dams, and earth-retaining structures. *Preq:* C E 321 or GEOL 320 or consent of instructor.
- C E 433, 633 Construction Planning and Scheduling 3(3,0)** Study of principles and applications of the Critical Path Method (CPM) and Project Evaluation and Review Techniques (PERT). Includes project breakdown and network graphics; identification of the critical path and resulting floats; definition and allocation of materials, equipment, and manpower resources; resource leveling, compression, and other network adjustments; and computer applications using packaged routines. *Preq:* C E 331 or consent of instructor.
- C E 434, 634 Construction Estimating and Project Control 3(3,0)** Instruction in specifications, contracts, and bidding strategies; purchasing and subcontracting policies; accounting for materials, supplies, subcontracts, and labor; procedural details for estimating earthwork, reinforced concrete, steel, and masonry. Also considers overhead and profit items. *Preq:* C E 331 or consent of instructor.
- C E 438, 638 Construction Support Operations 3(3,0)** Describes activities necessary for the completion of a construction job although not specifically recognized as direct construction activities: general conditions, safety, security, quality assurance, value engineering; organizational support features and typical implementation procedures. *Preq:* C E 331 and EX ST 301, or consent of instructor.
- C E 443, 643 Water Resources Engineering 3(3,0)** Extension of the concepts of fluid mechanics to applications in water supply, water resource assessment, water transmission, water distribution networks, pump and pipe selection, pipe networks, and analysis of open channel appurtenances. *Preq:* C E 341.
- C E 446, 646 Flood Hazards and Protective Design 3(3,0)** Study of flood hazards and methods of protective design of the built environment; floodplain mapping and delineation; methods for determining base flood elevations. Discusses flood-resistant construction, flood proofing, and governmental regulations. Includes case studies and design projects. *Coreq:* C E 342 or consent of instructor.
- C E 447, 647 Stormwater Management 3(3,0)** Evaluation of peak discharges for urban and rural basins, design of highway drainage structures such as inlets and culverts; stormwater and receiving water quality; best management practices, detention and retention ponds, and erosion and sediment control. *Preq:* C E 342; *Coreq:* EE&S 401 or consent of instructor.
- C E 448, 648 Physical Models in Hydraulics 3(2,3)** Tools and techniques of physical modeling to aid in design of complex hydraulic systems. Students participate in construction, operation, and testing of physical models to solve hydraulic engineering design problems. Experimental design and operation are covered. *Preq:* C E 342 or consent of instructor.

C E 449 649 Hydraulic Structures 3(3,0) Design methods and procedures are taught for a variety of hydraulic structures including intake structures, complex open-channel and closed conduit control structures, transitions, spillways, small dam, and pond design. Field trips to actual hydraulic structures may be included. *Preq:* C E 342 or consent of instructor.

C E 455, 655 Properties of Concrete and Asphalt 3(2,3) Properties of aggregate, concrete, and asphalt are discussed. Concrete and asphalt mix designs are conducted in the laboratory. *Preq:* C E 351 and EX ST 301, or consent of instructor.

C E 459 Capstone Design Project 3(1,6) Students apply creativity with their engineering knowledge in the solution of open-ended civil engineering problems. Problems are formulated and solutions are evaluated by faculty and practicing engineers. Oral communication skills are developed through presentations, correspondence, and project reports. *Preq:* All required 300-level C E courses and the Technical Design Requirement.

C E 462, 662 Coastal Engineering I 3(3,0) Introduction to coastal and oceanographic engineering principles, including wave mechanics, wave-structure interaction, coastal water-level fluctuations, coastal-zone processes, and design considerations for coastal structures and beach nourishment projects. *Preq:* C E 341 or consent of instructor.

C E 482, 682 Groundwater and Contaminant Transport 3(3,0) Basic principles of groundwater hydrology and transport of contaminants in groundwater systems; groundwater system characteristics; steady and transient flow; well hydraulics, design, and testing; contaminant sources, movement and transformations. *Preq:* C E 341. *Coreq:* EE&S 401.

C E H487 Senior Honors Project 1-3 Studies or laboratory investigations on special topics in civil engineering which are of interest to individual students and faculty members. Arranged on a project basis for a maximum of individual student effort under faculty guidance. May be repeated for a maximum of three credits. *Preq:* Senior standing in Civil Engineering Senior Departmental Honors Program.

C E H488 Honors Research I 2-3 Individual research under the direction of a Civil Engineering faculty member. *Preq:* C E H389.

C E H489 Honors Research II 3(3,0) Individual research under the direction of a Civil Engineering faculty member. *Preq:* C E H488

C E 490 Special Projects 1-3(1-3,0) Studies or laboratory investigations on special topics in civil engineering which are of interest to individual students and staff members. Arranged on a project basis with a maximum of individual student effort and a minimum of staff guidance. May be repeated for a maximum of three credits. *Preq:* Senior standing.

C E 491, 691 Selected Topics in Civil Engineering 1-6(1-6,0) Structured study of civil engineering topics not found in other courses. May be repeated for a maximum of six credits, but only if different topics are covered. *Preq:* Consent of instructor.

CLEMSON UNIVERSITY

C U 101 University Success Skills 2(3,0) Introduction to a variety of topics critical to students' success. Topics include time management, goal setting, test taking, campus resources and policies, critical thinking, and diversity. Students are given opportunities to discover and practice many procedures, techniques, and tips. Limited to freshmen and first semester transfer students.

COLLEGE OF ENGINEERING AND SCIENCE

CES 101 Introduction to Engineering and Science 3(1,4) Introduces engineering and science disciplines to assist students in selecting a major. Students use laptop computers to study spreadsheets, obtain graphical solution of problems, and use electronic sensors for data acquisition. Students complete team-based design projects. Provides a recitation for students who are not calculus-ready at matriculation. *Coreq:* MTHSC 103 or 105.

CES 102, H102 Engineering Disciplines and Skills 2(1,3) Introduction to engineering and science disciplines to assist students in selection of a major. Students use laptop computers to study spreadsheets, obtain graphical solution of problems, use electronic sensors for data acquisition, and respond to various on-line surveys. Students complete team-based design projects. *Coreq:* MTHSC 106 or above.

CES 110 Engineering and Science Workshop 1(0,2) Workshop that addresses issues and opportunities for women in science and engineering. Designed to help students succeed in engineering and science by strengthening their problem-solving, leadership, and teamwork skills and by introducing them to female role models and mentors in engineering and science.

CES 403, 603 Career Success in Research and Development 1(1,0) Assists students in making personal and professional transition into industrial research careers. Introduces and demonstrates practical advice and techniques to help students avoid early career land mines. *Preq:* Junior standing in engineering or science discipline.

COMMUNICATION STUDIES

Professor: K. W. Hawkins, *Chair; Associate Professors:* A. C. Billings, B. E. Denham, D. S. Geddes, S. R. Mazzarella; *Assistant Professors:* P. J. Bowers, K. O. Jones, D. R. Novak, D. W. Wiesman, D. P. Wolfe, J. Yin; *Lecturers:* C. O. Bishop, J. W. Drye, K. Harp, E. E. Hegel, K. M. Lauridsen, C. A. Lossie, C. S. Parsons, E. D. Ryalls, T. M. Schurz, E. R. Smith, A. M. Zachary

COMM 101 Communication Academic and Professional Development I 1(1,0) Introduces students to General Education and Communication Studies major requirements, explains connections between general education and major courses, explores careers in communication, and prepares students to develop digital portfolios, résumés, and interview skills specific to communication professions and/or graduate school. To be taken Pass/Fail only.

COMM 107 Media Representations of Science and Technology 3(3,0) Examines mediated representations of science and technology from a communication perspective. Attention is paid to portrayals/coverage of science and technology in popular film, television, Internet, journalism, and other media. Students examine an array of theoretical issues and case studies in this area.

COMM 150 Introduction to Human Communication 3(2,2) Overview of theoretical approaches to the study of communication, including the theory and practice of interpersonal/small group/intercultural/public communication. Students complete a portfolio. Includes a laboratory.

COMM 162 Forensic Laboratory 1(0,3) Research, preparation, and practice leading to participation in on-campus and intercollegiate debate and individual events competition. May be repeated for a maximum of four credits.

COMM 163 Advanced Forensic Laboratory 1(0,3) Advanced research, preparation, and practice leading to continued participation in on-campus and intercollegiate debate and individual events competition. May be repeated for a maximum of four credits. *Preq:* COMM 162.

COMM 201 Introduction to Communication Studies 4(3,2) Introduces Communication Studies majors to and prepares them for continued study in the discipline by providing them with an overview of important issues, areas of study, and approaches to the field. Includes a writing laboratory experience. *Preq:* COMM 101.

COMM 250, H250 Public Speaking 3(3,1) Practical instruction in public speaking; practice in the preparation, delivery, and criticism of short speeches. Develops an understanding and knowledge of the process of communication. Students complete a portfolio. Includes a laboratory.

COMM 256 Introduction to Public Relations 3(3,0) Students learn the context and techniques of public relations (PR), a form of corporate communications. Types of PR work, theories of PR, the four-part structure of PR, and the history of the field.

COMM 300 Communication in a World Context 3(3,0) In-depth examination of differences in communication practices and meanings seen through a global perspective. *Preq:* COMM 201 with a C or better or consent of instructor.

COMM 301 Communication Theory 3(3,0) Students explore the breadth and depth of theories within the major frameworks of the communication studies discipline. Students select the creative inquiry topic on which they will write a review of the literature. Precedes COMM 310, 311, and 495 in the creative inquiry experience. *Preq:* COMM 201 with a C or better or consent of instructor.

COMM 302 Mass Communication Theory 3(3,0) Survey of the breadth and history of theories of mass communication and mass media from the 19th century to the present. Emphasizes contemporary schools of thought, theoretical debates, and the continuing controversies in the field. *Preq:* COMM 201 with a C or better or consent of instructor.

- COMM 303 Communication Law and Ethics 3(3,0)** Major topics in communication law and free expression and in communication ethics. *Preq:* COMM 201 with a C or better or consent of instructor.
- COMM 304 Youth, Media, and Culture 3(3,0)** Grounded in the cultural studies paradigm, examines the relationship among youth, mass media, and popular culture. Focuses on issues such as how youth are portrayed in media, how youth navigate the products of mass media/culture, and how youth creates its own media culture. *Preq:* COMM 201 with a C or better or consent of instructor.
- COMM 305 Persuasion 3(3,0)** Study of the processes by which communication influences attitudes, beliefs, and behaviors in our personal, social, civic, and professional lives. After discussion of definitional and methodological issues, particular theories of persuasion are examined. Treatment of political, market-driven, and social persuasion concludes the course. *Preq:* COMM 201 with a C or better or consent of instructor.
- COMM 306 Discourse and Society 3(3,0)** Examines historical and contemporary theoretical and critical approaches to the description, analysis, interpretation, and evaluation of public discourse. Focuses on the power of public discourse to shape human existence. *Preq:* COMM 201 with a C or better or consent of instructor.
- COMM 307 Public Communication of Science and Technology 3(3,0)** Examines the role of science and technology in society from a communication perspective. Particular attention is paid to this dynamic in public culture. Students examine an array of theoretical issues and case studies in this area. *Preq:* COMM 201 with a C or better or consent of instructor.
- COMM 308 Public Communication and Popular Culture 3(3,0)** Examines artifacts of popular culture, paying particular attention to their relationship to politics and public life. Explores the structures and constraints of the culture industry. Students apply communication principles to various examples. *Preq:* COMM 201 with a C or better or consent of instructor.
- COMM 309 Visual Discourse and the Public 3(3,0)** Examines the role of visuality in society and the cultural implications for ways of seeing. Using visual artifacts of various types, students learn the logic of visual representation. *Preq:* COMM 201 with a C or better or consent of instructor.
- COMM 310 Quantitative Research Methods in Communication Studies 3(3,0)** Explores methods of quantitative communication inquiry including theory/research relationship, conducting studies, and utilizing SPSS. Methods may include experiments, surveys, and content analysis. Concepts build from the literature review completed in COMM 301 as part of student's creative inquiry experience. May be taken before, concurrently with, or after COMM 311. *Preq:* COMM 301 with a C or better or consent of instructor.
- COMM 311 Qualitative Research Methods in Communication Studies 3(3,0)** Explores methods of qualitative communication inquiry including theory/research relationship, and conducting studies. Methods may include interviewing, focus groups, textual analysis, and ethnography. Concepts build from the literature review completed in COMM 301 as part of student's creative inquiry experience. May be taken before, concurrently with, or after COMM 310. *Preq:* COMM 301 with a C or better or consent of instructor.
- COMM 320 Television Journalism 3(2,2)** Explores both the philosophy of journalism and the applied skills of the journalist. In addition to classroom activities, students experience television journalism first-hand as participants on a weekly on-campus television news program.
- COMM 325 Sports Communication 3(3,0)** Covers fundamentals of communicating in a sports environment. Includes the basics of communicating for print and broadcast news, as well as communicating for public relations and sports information. Also covers ethical considerations and the role of sports in American culture. *Preq:* COMM 201 with a C or better or consent of instructor.
- COMM 326 Public Relations in Sports 3(3,0)** Focuses on the preparation of professional sports communication materials for both internal and external audiences. Topics include the mechanics of creating press releases and other materials, as well as techniques in managing crises. *Preq:* COMM 201 with a C or better or consent of instructor.
- COMM 327 Sports Media Criticism 3(3,0)** Students gain in-depth understanding of sports communication issues through critically analyzing actual media coverage of sporting events, addressing social issues involved in college and professional sports, and developing an understanding of sports promotion and advertising. *Preq:* COMM 201 with a C or better or consent of instructor.
- COMM 330 Nonverbal Communication 3(3,0)** Develops a knowledge of the functions of nonverbal behaviors in human interaction. This includes the study of gesture and movement, physical appearance, vocal behavior, immediacy, time and space, and intercultural differences. Promotes understanding of nonverbal rules. *Preq:* COMM 201 with a C or better or consent of instructor.
- COMM 348 Interpersonal Communication 3(3,0)** Survey of the theories and research in interpersonal communication with emphasis on the application of research findings and developmental strategies for intra- and intercultural relationships. *Preq:* COMM 201 with a C or better or consent of instructor.
- COMM 349 Communication and Aging 3(3,0)** Major theories and concepts concerning communication with and between members of aging populations. Focuses on communication factors that affect the elderly and implications for the creation and maintenance of satisfying relationships within and between generations. *Preq:* COMM 201 with a C or better or consent of instructor.
- COMM 350 Small Group and Team Communication 3(3,0)** Examines the principles and skills involved in effective small-group communication. *Preq:* COMM 201 with a C or better or consent of instructor.
- COMM 356 Stakeholder Communication 3(3,0)** Focuses on external stakeholders such as the media, the community, and the government. Students learn how to manage various stakeholder relationships. *Preq:* COMM 256 or consent of instructor.
- COMM 361 Argumentation and Debate 3(3,0)** Basic principles of argumentation with emphasis on developing skills in argumentative speech. The role of the advocate in contemporary society with an emphasis on and an appreciation of formal debate. *Preq:* COMM 250 or consent of instructor.
- COMM 362 Communication and Conflict Management 3(3,0)** Introduces the study of communication practices in conflict situations within various personal and professional settings. Emphasis is on the central role of communication in the understanding and management of conflict. *Preq:* COMM 201 with a C or better or consent of instructor.
- COMM 364 Organizational Communication 3(3,0)** Examination of the process, theories, and techniques of communications within small groups and other organized bodies. *Preq:* COMM 201 with a C or better or consent of instructor.
- COMM 366 Special Topics in Communication Studies 3(3,0)** Consideration of select major areas of study in the field. With consent of department chair, may be repeated for a maximum of 15 credits, but only if different topics are covered.
- COMM 368 Organizational Communication Simulation 3(3,0)** Students develop and apply communication skills which are useful in a variety of organizational settings: taking and conducting interviews, group decision making, and oral reporting. Discusses communication processes and provides personal and professional development. *Preq:* COMM 201 with a C or better and COMM 250 or consent of instructor.
- COMM 369 Political Communication 3(3,0)** Examination of American political rhetoric after 1900, focusing on such notable speakers as Franklin D. Roosevelt, John F. Kennedy, and Martin Luther King, Jr. *Preq:* COMM 201 with a C or better or consent of instructor.
- COMM 390 Communication Studies Internship 3(0,9)** Preplanned, preapproved, faculty-supervised internship provides Communication Studies majors with field experience in areas related to their curriculum. May be repeated for a maximum of six credits. To be taken Pass/Fail only. *Preq:* Junior standing, consent of faculty advisor.
- COMM 402 Mass Communication: History and Criticism 3(3,0)** Critical examination of mass communication in America, including discussions of history, theory, and current issues in television, film, popular music, telecommunications, and other media. *Preq:* COMM 201 with a C or better or consent of instructor.
- COMM 405 Public Contest and Change 3(3,0)** Examines the role of public communication in the process of contesting social values and practices and in the subsequent change that sometimes occurs. Students explore the public's relationship with mass media as well as other forms of communication practices that can produce cultural change. *Preq:* COMM 201 with a C or better or 305 or consent of instructor.

COMM 425 Advanced Sports Communication 3(3,0) Combination seminar and primary research class that explores contemporary sports communication issues. Students write position papers on seminar topics and conduct primary research on sports communication topics of their choice. *Preq:* COMM 325 or consent of instructor.

COMM (ENGL) 451, 651 Film Theory and Criticism 3(2,3) See ENGL 451.

COMM 455 Gender Communication 3(3,0) Explores the ways communication behavior and perceptions of communication behavior are affected by gender. The effects of gender on a variety of communication contexts are examined, including interpersonal, small group, organizational, and mass communication. *Preq:* COMM 201 with a C or better or consent of instructor.

COMM 456, 656 Crisis Communication 3(3,0) In-depth examination of the use of communication in planning, managing, and responding to organizational crisis. *Preq:* COMM 256 or consent of instructor.

COMM 462 Communication and Negotiation 3(3,0) Building on the concepts and practices of conflict management, students develop knowledge and skills for distributive bargaining and integrative negotiation climates. Focuses on the objectives, goals, positions, interests, tactic, and other elements to successfully negotiate in a variety of situations. *Preq:* COMM 362 or consent of instructor.

COMM 464, 664 Advanced Organizational Communication 3(3,0) Application of speech communication methodology to the analysis of organizational communication processes. Students study methods of organizational communication analysis and intervention. *Preq:* COMM 364 or consent of instructor.

COMM 470, 670 Communication and Health 3(3,0) Considers institutional and health care communication issues as well as the relationship between social issues, communication, and health. *Preq:* COMM 201 with a C or better or consent of instructor.

COMM 480 Intercultural Communication 3(3,0) Introduces the process of communication between and among individuals from different cultures or subcultures. Emphasizes the effect of cultural practices within various communication relational contexts such as interpersonal, small group, and organizational communication. *Preq:* COMM 201 with a C or better or consent of instructor.

COMM (ENGL) 491, 691 Classical Rhetoric 3(3,0) See ENGL 491.

COMM (ENGL) 492, 692 Modern Rhetoric 3(3,0) See ENGL 492.

COMM H493 Honors Prospectus Project 1(1,0) Completion of an honors project proposal and a prospectus meeting with a faculty committee. First in a three-course sequence with H494 and H496. *Preq:* COMM 301, 310.

COMM H494 Honors Field Research 3(0,9) Honors students in Communication Studies pursue field work with an outside organization related to concentration area in the major, gathering data for use in preparing original research project for COMM H496. Second in a three-course sequence with H493 and H496. *Preq:* COMM H493.

COMM 495 Creative Inquiry Capstone 3(3,0) Capstone course in the Department's creative inquiry sequence that builds on students' prior work in communication theory and research methods. Students apply their theoretical understanding and research skills in completing a significant research project involving their previously selected topics. Project culminates in written, oral, and visual presentations. *Preq:* COMM 310 and 311 with a C or better, Senior standing in Communication Studies, or consent of instructor.

COMM H496 Honors Senior Communication Seminar 3(3,0) Plans developed in COMM H493 and data gathered from COMM H494 are applied to the production of a written product of conference or publication length and quality. Third in a three-course sequence with H493 and H494. *Preq:* COMM H493, H494.

COMM 498 Communication Academic and Professional Development II 1(1,0) Students reflect upon curricular relationships among general education, major, and minor courses. They complete and revise digital portfolios for presentation to the major, University, graduate schools, or potential employers. Students participate in résumé building, job seeking, and interviewing activities. *Preq* or *Coreq:* COMM 495 or H496.

COMM 499 Independent Study 1-3(1-3,0) Tutorial work for students with special interests or projects in speech communication outside the scope of existing courses. *Preq:* Consent of department chair.

COMMUNITY AND RURAL DEVELOPMENT

See also courses listed under *Agricultural and Applied Economics*.

Professors: D. L. Barkley, M. Espey, M. S. Henry, J. C. O. Nyankori; *Associate Professor:* S. R. Templeton; *Assistant Professor:* K. L. Robinson

C R D (SOC) 235 Introduction to Leadership 3(3,0) See SOC 235.

C R D 335 Leadership in Organizations and Communities 3(3,0) Students present leadership models, principles, skills, negotiation techniques, and practices to improve effectiveness in organizations and communities; use current theory and research findings to evaluate effective leadership; demonstrate the role of effective leadership in shaping future organizations and social structures in public and private sectors. *Preq:* Introductory course in a social science (sociology recommended).

C R D 336 Community Development Methods 3(3,0) Research methodology is applied to community, leadership, and economic development. Steps include problem identification, data collection, analysis, and interpretation. Special attention is given to case study approach, applied research design, data collection options, and computer-based analysis of community-based data to generate findings and implications for policy change. *Preq:* C R D 335, EX ST 301 or equivalent.

C R D 357 Natural Resources Economics 3(3,0) Principles and problems involved in the use of soil, water, forest, and mineral resources, with special emphasis on economic aspects of alternative methods of resource utilization. *Preq:* AP EC 202, ECON 200 or 211.

C R D (AP EC, HLTH) 361 Introduction to Health Care Economics 3(3,0) Introductory course in which students learn the basic economics of the institutions comprising the health-care industry. Topics include the underlying supply, demand, and institutional factors impacting health-care availability and cost of health care.

C R D (AP EC) 411, 611 Regional Impact Analysis 3(3,0) Techniques for analysis of the growth and decline of regions including economic-base theory, shift share, regional input-output, regional econometric models, and fixed impact models. *Preq:* AP EC 202 or ECON 211 and 212.

C R D (AP EC) 412, 612 Regional Economic Development Theory and Policy 3(3,0) Development of rural economic activity in the context of historical, theoretical, and policy aspects of friction associated with spatial separation. Considers location factors, transfer costs, location patterns, and regional-growth policy. *Preq:* AP EC 202 or ECON 211 or equivalent.

C R D (AP EC) 491 Internship, Agribusiness, and Community and Rural Development 1-6(0,2-12) Internship under faculty supervision in an approved agency or firm. Internships provide students with work experience in agribusiness or community and rural development. Students submit a comprehensive report within one week of the end of the internship. A maximum of six internship credits may be earned. *Preq:* Junior standing and/or consent of instructor.

C R D 492, 692 Case Study Project 3(3,0) Capstone course engaging students in in-depth case study projects in community and economic development. Designed to enhance professional development, career interests, and practical experience. Students may participate in an internship, field experience, service learning activity, or investigation of a community, leadership, or economic development topic. *Preq:* C R D 336 and consent of instructor.

COMPUTER SCIENCE

Professors: R. M. Geist III, S. M. Hedetniemi, S. T. Hedetniemi, D. P. Jacobs, M. Sitaraman, P. K. Sriamani, *Chair:* J. M. Westall, Jr.; *Associate Professors:* A. T. Duchowski, W. Goddard, H. C. Grossman, A. W. Madison, B. A. Malloy, J. D. McGregor, R. P. Pargas, M. K. Smotherman, D. E. Stevenson; *Assistant Professors:* T. A. Davis, B. C. Dean, J. O. Hallstrom, J. J. Martin, Z. Wang, M. C. Weigle; *Lecturers:* C. Hochrine, J. H. Jones, R. S. Lambert, R. M. Lowe, C. F. Pellerin, P. D. Sterling, K. A. Weaver

CP SC 101, H101 Computer Science I 4(3,2) Introduction to modern problem solving and programming methods. Special emphasis is placed on algorithm development and software life cycle concepts. Includes use of appropriate tools and discusses ethical issues arising from the impact of computing upon society. Intended for students concentrating in computer science or related fields. *Preq:* MTHSC 105 or satisfactory score on the Clemson Mathematics Placement Test or consent of instructor.

- CP SC 102, H102 Computer Science II 4(3,2)** Continuation of CP SC 101. Continued emphasis on problem solving and program development techniques. Examines typical numerical, nonnumerical, and data processing problems. Introduces basic data structures. Credit may not be received for both CP SC 102 and 210. *Preq:* CP SC 101 with a C or better.
- CP SC 104 Introduction to the Concepts and Logic of Computer Programming 2(1,2)** Introduction to the concepts and logic of computer programming. Simple models are used to introduce basic techniques for developing a programmed solution to a given problem. Problem solving techniques are considered. Not open to students who have received credit for CP SC 101, 111, 157, or 210.
- CP SC 110, H110 Elementary Computer Programming 3(3,0)** Introduction to computer programming and its use in solving problems. Intended primarily for technical majors. Basic instruction in programming techniques is combined with tools use and discussions of ethical issues arising from the impact of computing on society.
- CP SC 111 Elementary Computer Programming in C/C++ 3(2,2)** Introduction to computer programming in C/C++ and its use in solving problems. Intended primarily for technical majors. Basic instruction in programming techniques is combined with tools use and discussions of ethical issues arising from the impact of computing on society.
- CP SC 115 Introduction to Computational Science 3(3,0)** Introduction to systems thinking. Includes development of dynamical systems models using visual modeling tools and development of dynamical systems using agent based software. Class material investigates elementary science and engineering models.
- CP SC 120 Introduction to Information Technology 3(2,2)** Investigation of ethical and societal issues based on the expanding integration of computers into our everyday lives. Considers historical background, terminology, new technologies and the projected future of computers. Includes practical experience with common computer software technologies. Will not satisfy Computer Science Requirements in any Computer Science major.
- CP SC 157 Introduction to C Programming 2(2,0)** Introduction to basic programming techniques using the C programming language.
- CP SC 161 Introduction to Visual Basic Programming 3(2,2)** Introduction to programming using the Visual Basic language. Topics include simple and complex data types, arithmetic operations, control flow, files, and database programming. Several projects are implemented during the semester.
- CP SC 210 Programming Methodology 4(3,2)** Introduction to programming techniques and methodology. Topics include structured programming, stepwise refinement, program design and implementation techniques, modularization criteria, program testing and verification, basic data structures, and analysis of algorithms. Credit may not be received for both CP SC 102 and 210. *Preq:* CP SC 111 or equivalent; satisfactory performance on a pretest.
- CP SC 212 Algorithms and Data Structures 4(3,2)** Study of data structures and algorithms fundamental to computer science; abstract data-type concepts; measures of program running time and time complexity; algorithm analysis and design techniques. *Preq:* CP SC 102 or 210 with a C or better.
- CP SC 215 Tools and Techniques for Software Development 3(2,2)** Intensive course on software development using an imperative language. Topics include typical program development tools such as debuggers and "make" files, software development and testing techniques such as separate module development and testing, pointers and explicit heap management, and low-level file I/O. *Preq:* CP SC 102 or 210 with a C or better.
- CP SC 220 Microcomputer Applications 3(3,0)** Applications of microcomputers to formulate and solve problem models. Emphasizes applications development in database and spreadsheet environments. Current software products are used. *Preq:* CP SC 120 or MGT 218 or equivalent.
- CP SC 231 Introduction to Computer Organization 4(3,2)** Study of the machine architectures on which algorithms are implemented and requirements of architectures that support high-level languages, programming environments, and applications. *Preq:* CP SC 102 or 210 with a C or better.
- CP SC 281 Selected Topics in Computer Science 1-4(0-3,0-6)** Areas of computer science in which new trends arise. Innovative approaches to a variety of problems in the use and understanding of basic computing concepts are developed and implemented. May be repeated for a maximum of eight credits, but only if different topics are covered. *Preq:* Consent of instructor.
- CP SC 291 Seminar in Professional Issues I 1(1,0)** Considers the impact of computer use on society. Discusses ethical use of software and protection of intellectual property rights. Profession is viewed historically; organizations important to the profession are discussed; the development process for standards is presented; and students are introduced to the professional literature. *Preq:* CP SC 102 or 210, or consent of instructor.
- CP SC 322 Introduction to Operating Systems 3(3,0)** Detailed study of management techniques for the control of computer hardware resources. Topics include interrupt systems, primitive level characteristics of hardware and the management of memory, processor, devices, and data. Credit may not be received for both CP SC 322 and 332. *Preq:* CP SC 215, 231 with a C or better.
- CP SC 330 Computer Systems Organization 3(3,0)** Introduction to the structure of computer systems. Various hardware/software configurations are explored and presented as integrated systems. Topics include digital logic, basic computer organization, computer arithmetic, memory organization, input/output organizations, interrupt processing, multiprocessors, and cluster computers. *Preq:* CP SC 212, 215, 231 with a C or better.
- CP SC 332 Computer Systems 3(3,0)** Introduces design, integration, and use of hardware and software components in standard computer systems. Emphasizes computer organization at the component level, interfacing, basic operating system functions, and system utilities. Credit may not be received for both CP SC 322 and 332. *Preq:* CP SC 212, 215, 231 with a C or better.
- CP SC 350 Foundations of Computer Science 3(3,0)** Development of the theoretical foundations of programming, algorithms, languages, automata, computability, complexity, data structures, and operating systems; a broad range of fundamental topics is consolidated and extended in preparation for further study. *Preq:* CP SC 212 and MTHSC 119 with a C or better.
- CP SC 360 Networks and Network Programming 3(3,0)** Introduction to basic concepts of computer network technologies and network programming. Topics include network programming, layered protocol architectures, local and wide area networks, internetwork and intranetwork concepts, security. Socket level programming is introduced and used throughout the course. *Preq:* CP SC 212, 215 with a C or better.
- CP SC 361 Data Management Systems Laboratory 1(0,2)** Introduction to mainframe environments typical of large-scale data processing applications; programming languages, control languages, and file utilities; use of COBOL language and IBM JCL. *Preq:* CP SC 102 or 210; or equivalent. *Coeq:* CP SC 360.
- CP SC 362 Distributed and Cluster Computing 3(3,0)** Introduction to the basic technology of and programming techniques for distributed and cluster computing. Standard techniques for developing parallel solutions to problems are introduced and implemented. Software systems that provide high-level abstractions for data communications are considered. *Preq:* CP SC 360 with a C or better.
- CP SC 371 Systems Analysis 3(3,0)** Incorporates a study of the decision-making process at all levels with the logical design of information systems. Extensive study of the system life cycle with emphasis on current as well as classical techniques for describing data flows, data structures, file design, etc. *Preq:* CP SC 360.
- CP SC 372 Introduction to Software Development 3(3,0)** Introduces techniques and issues in software design and development; tools, methodologies, and environments for effective design, development, and testing of software; and organizing and managing the development of software projects. *Preq:* CP SC 212 and 215 with a C or better.
- CP SC H395 Honors Seminar 1(1,0)** Research topics in various areas of computer science are presented. Methods for identifying and initiating research projects are considered. May be repeated for a maximum of two credits. *Preq:* Admission to Departmental Honors Program.
- CP SC 405, 605 Introduction to Graphical Systems Design 3(3,0)** Study of principles, computational techniques, and design concepts needed for designing systems for effective graphical displays. *Preq:* CP SC 212, 215, MTHSC 108, 311 with a C or better.

CP SC 411, 611 Virtual Reality Systems 3(3,0)

Design and implementation of software systems necessary to create virtual environments. Discusses techniques for achieving real-time, dynamic display of photorealistic, synthetic images. Includes hands-on experience with electromagnetically-tracked, head-mounted displays and requires, as a final project, the design and construction of a virtual environment. *Preq:* CP SC 405 with a C or better.

CP SC 412, 612 Eye Tracking Methodology and Applications 3(3,0)

Introduction to the human visual system; visual perception; eye movements; eye tracking systems and applications in psychology, industrial engineering, marketing, and computer science; hands-on experience with real time, corneal-reflection eye trackers, experimental issues. Final project requires the execution and analysis of an eye tracking experiment. *Preq:* CP SC 360, MKT 431, or PSYCH 310.

CP SC 414, 614 Human and Computer Interaction 3(3,0)

Survey of human and computer interaction, its literature, history, and techniques. Covers cognitive and social models and limitations, hardware and software interface components, design methods, support for design, and evaluation methods. *Preq:* CP SC 212 and 215 with a C or better, or equivalent.

CP SC 416, 616 2-D Game Engine Construction 3(3,0)

Introduction to tools and techniques necessary to build 2-D games. Techniques draw from subject areas such as software engineering, algorithms, and artificial intelligence. Students employ techniques such as sprite animation, parallax scrolling, sound, AI incorporated into game sprites, and the construction of a game shell. *Preq:* CP SC 212 and 215 with a C or better.

CP SC 420, 620 Computer Security Principles 3(3,0)

Covers principles of information systems security, including security policies, cryptography, authentication, access control mechanisms, system evaluation models, auditing, and intrusion detection. Computer security system case studies are analyzed. *Preq:* CP SC 322 and 360 with a C or better.

CP SC 424, 634 System Administration and Security 3(3,0)

Covers topics related to the administration and security of computer systems. Primary emphasis is on the administration and security of contemporary operating systems. *Preq:* CP SC 360 and 322 or 332 with a C or better.

CP SC 428, 628 Design and Implementation of Programming Languages 3(3,0)

Overview of programming language structures and features and their implementation. Control and data structures found in various languages are studied. Also includes runtime organization and environment and implementation models. *Preq:* CP SC 231, 350, 360 with a C or better.

CP SC 455, 655 Computational Science 3(3,0)

Introduction to the methods and problems of computational science. Uses problems from engineering and science to develop mathematical and computational solutions. Case studies use techniques from Grand Challenge problems. Emphasizes the use of networking, group development, and modern programming environments. *Preq:* MTHSC 108, 311, and previous programming experience in a higher level language.

CP SC 462, H462, 662 Database Management Systems 3(3,0)

Introduction to database/data communications concepts as related to the design of online information systems. Problems involving structuring, creating, maintaining, and accessing multiple-user databases are presented and solutions developed. Comparison of several commercially available teleprocessing monitor and database management systems is made. *Preq:* CP SC 360.

CP SC 463, 663 On-line Systems 3(3,0)

In-depth study of the design and implementation of transaction processing systems and an introduction to basic communications concepts. A survey of commercially available software and a project using one of the systems are included. *Preq:* CP SC 462.

CP SC 464, 664 Introduction to Computer Architecture 3(3,0)

Survey of von Neumann computer architecture at the instruction-set level. Fundamental design issues are emphasized and illustrated using historical and current mainframe, supermini, and micro architecture. *Preq:* CP SC 330 or consent of instructor.

CP SC 472, H472, 672 Software Development Methodology 3(3,0)

Advanced topics in software development methodology. Techniques such as chief programmer teams, structured design and structured walk-throughs are discussed and used in a major project. Emphasizes the application of these techniques to large-scale software implementation projects. Also includes additional topics such as mathematical foundations of structured programming and verification techniques. *Preq:* CP SC 360 and 372.

CP SC 481, H481, 681 Selected Topics 1-3(1-3,0)

Areas of computer science in which non-standard problems arise. Innovative approaches to problem solutions which draw from a variety of support courses are developed and implemented. Emphasizes independent study and projects. May be repeated for a maximum of six credits, but only if different topics are covered. *Preq:* Consent of instructor.

CP SC 491 Seminar in Professional Issues II 1(1,0)

Considers the impact of computing system development on society. Discusses ethical issues in the design and development of computer software. Students discuss standards for professional behavior, the professional's responsibility to the profession, and techniques for maintaining currency in a dynamic field. *Preq:* Senior standing.

CP SC H495 Senior Thesis Research 1-3(1-3,0)

Directed individual research project for honors students supervised by departmental faculty. May be repeated for a maximum of six credits. *Preq:* Senior standing.

CONSTRUCTION SCIENCE AND MANAGEMENT

Professors: F. M. Eubanks, R. W. Liska, *Chair*; *Associate Professors:* S. N. Clarke, G. R. Corley, C. A. Piper, R. K. Schneider; *Assistant Professor:* D. C. Bausman

C S M 100 Introduction to Construction Science and Management 3(3,0)

Introduction to the construction industry and the Construction Science and Management Department. *Preq:* Construction Science and Management major or consent of department chair.

C S M 150 Introduction to Research Methodology 1(0,2)

Fundamentals of formal research methodology, critical thinking, and ethics. *Preq:* Construction Science and Management major.

C S M 201 Structures I 3(3,0)

Study of statically determinate structural components and systems including force applications and distributions in structural elements and the resulting stress-strain patterns in axial, shear, and bearing mechanisms. *Preq:* MTHSC 102 or 106, PHYS 207; Construction Science and Management or Architecture major, or consent of department chair.

C S M 202 Structures II 4(3,2)

Study of force distribution and behavior in statically determinate structural components and systems; analysis and design of basic reinforced concrete, steel, wood, and formwork components and systems including shear and moment stress, combined loading/stress conditions, and deflections. *Preq:* C S M 201, Construction Science and Management or Architecture major, or consent of department chair.

C S M 203 Materials and Methods of Construction I 3(3,0)

Descriptive study of the materials and methods of construction, focusing on nomenclature, building materials, and assembly of building systems consisting primarily of wood, masonry, residential interior and exterior finishes, and building foundations. *Preq:* Construction Science and Management or Architecture major, or consent of department chair. *Preq or Coreq:* A A H 210, C S M 100 (Construction Science and Management majors).

C S M 204 Contract Documents 3(2,3)

Introduction to working drawings, specifications, and the various documents required to carry out a typical construction project. *Preq:* Construction Science and Management major or consent of department chair. *Coreq:* C S M 205.

C S M 205 Materials and Methods of Construction II 3(3,0)

Descriptive study of materials and methods of construction, focusing on nomenclature, building materials, and assembly of building systems consisting primarily of steel and concrete in addition to roofing assemblies and interior and exterior commercial finishes. *Preq:* C S M 203, Construction Science and Management or Architecture major, or consent of department chair.

C S M 250 Construction Problem Solving Through Research 1(0,2)

Application of the components of formal research methodology to real-life construction problems and documentation and presentation of process and solution. *Preq:* C S M 150 or consent of department chair.

- C S M 301 Structures III 3(3,0)** Analysis and design of basic determinate and indeterminate masonry and reinforced concrete structural components and systems; introduction to special structural systems and seismic loading. *Preq:* C S M 202, PHYS 208, Construction Science and Management or Architecture major, or consent of department chair.
- C S M 303 Soils and Foundations 3(2,3)** Study of various types of soils and foundations, including soil testing, reports, compaction, stability, and function as they relate to the construction process. *Preq:* C S M 202, Construction Science and Management major, or consent of department chair.
- C S M 304 Environmental Systems I 3(3,0)** Theory and practice of heating, ventilating, air conditioning, and plumbing systems for buildings. *Preq:* C S M 205, PHYS 208, Construction Science and Management or Architecture major, or consent of department chair.
- C S M 305 Environmental Systems II 3(3,0)** Theory and practice of fire protection, specialty piping, lighting, and electrical systems for buildings. *Preq:* C S M 304, Construction Science and Management or Architecture major, or consent of department chair.
- C S M 351 Construction Estimating 3(2,2)** Study of basic estimating as applied to construction projects. Includes the take-off of material quantities, assigning labor and equipment production rates, and applying material prices, wage rates, and equipment costs to derive a total job cost. *Preq:* C S M 204, 205, CPSC 120, all required MTHSC courses, Construction Science and Management major, or consent of department chair. *Preq or Coreq:* B E 222, C S M 303.
- C S M 352 Construction Scheduling 3(2,2)** Analysis of construction projects emphasizing estimating, scheduling, and resource leveling. *Preq:* C S M 304 (or concurrent enrollment), 351, Construction Science and Management major, or consent of department chair. *Coreq:* C S M 353.
- C S M 353 Construction Estimating II 3(2,2)** Continuation of basic construction estimating with the additional component of computerized estimating. Includes material, labor and equipment costs, production rates, bid ethics, construct-ability analysis, and understanding of other types of estimating procedures. *Preq:* C S M 304 (or concurrent enrollment), 351, Construction Science and Management major, or consent of department chair. *Coreq:* C S M 352.
- C S M 411 Safety in Building Construction 3(3,0)** Study of construction safety management and controls. *Preq:* Construction Science and Management major or consent of department chair. *Coreq:* C S M 453.
- C S M 420 Highway Construction and Contracting 3(3,0)** Study of contracting and construction of highways, including selection and use of equipment, construction of pavements, bridges, and drainage structures, and related processes. *Preq:* C S M 303, 352, 353.
- C S M 450 Construction Internship 1(1,0)** Documentation of 800 hours of approved experience in the construction industry with evaluation of student portfolio and preparation and sitting for the American Institute of Constructors CPC Level I examination. To be taken Pass/Fail only. *Preq:* C S M 250 or consent of department chair.
- C S M 453 Construction Project Management 3(3,0)** Study of construction business organization, methods of project delivery, field organization, policy, ethics, project management, control systems, labor management relations, and productivity. *Preq:* C S M 352, 353, LAW 322 (or concurrent enrollment), MGT 307 (or concurrent enrollment), Construction Science and Management major, or consent of department chair. *Coreq:* C S M 411, 461.
- C S M 454 Construction Capstone 6(3,12)** Students develop a capstone project that entails the knowledge obtained in all previous courses in the Construction Science and Management Program. Students must take the capstone course at Clemson University. *Preq:* C S M 453, Construction Science and Management major, or consent of department chair.
- C S M 455, 655 Reducing Adversarial Relations in Construction 3(3,0)** Focuses on the study of the delivery of projects and how adversarial relations can affect the successful completion of the venture. Topics include management of human resources, understanding the needs and processes of the participants, where problems lie, methods of avoiding and settling disputes. *Preq:* Construction Science and Management or Architecture major, senior standing, or consent of department chair.
- C S M 461 Construction Economics Seminar 3(3,0)** Studies in the financial performance of construction companies. *Preq:* ACCT 201, ECON 211, 212, Construction Science and Management major, or consent of department chair. *Coreq:* C S M 453.
- C S M 490, H490 Directed Studies 1-3(1-3,0)** Comprehensive studies and research of special topics not covered in other courses. Emphasizes field studies, research activities, and current developments in construction science. May be repeated for a maximum of six credits. *Preq:* Consent of instructor.
- C S M 498 Current Topics in Construction 1-3(1-3,0)** Study of current topics in the construction industry not central to other construction science courses. Specific titles and course descriptions to be announced from semester to semester. May be repeated for a maximum of six credits. *Preq:* Consent of advisor.
- CROP AND SOIL ENVIRONMENTAL SCIENCE**
Professors: H. T. Knap, V. L. Quisenberry, E. R. Shipe; *Associate Professors:* J. Andrae, W. C. Stringer; *Assistant Professor:* Y. Arai; *Lecturer:* B. E. Edge
- CSENV 100 Introduction to Crop and Soil Environmental Science 1(1,0)** Introduction to and survey of the agronomic and soil sciences and their application to current societal issues: career guidance, opportunities for professional certification, and discussion of skills used by agronomists and soil scientists. Offered fall semester only.
- CSENV 202 Soils 4(3,2)** Introduces world land resources, soil formation, classification, and mineralogy. Emphasizes basic chemical and physical properties of soil. Also discusses soil microorganisms, plant nutrients, and fertilization. Soil properties are related to growth. *Preq:* CH 101, 102, or a geology sequence including GEOL 101; or consent of instructor.
- CSENV 350 Practicum 1-6** Preplanned practical or research experience related to student-selected Soils and Sustainable Crop Systems concentration. Practicum is undertaken with an approved advisor or agency. May be repeated for a maximum of six credits. *Preq:* Soils and Sustainable Crop Systems major or consent of department chair.
- CSENV 403, 603 Soil Genesis and Classification 2(1,3)** Study of soil morphology and characterization, pedogenic processes, soil-forming factors, and classification of soils. Offered fall semester only. *Preq:* CSENV 202 or consent of instructor.
- CSENV 404, 604 Soils and Land Use 2(1,3)** Soils interpretations for nonagricultural purposes and facilities. Emphasizes use of modern soil surveys and properties and features of soils important in nonfarm land uses. Not open to Crop and Soil Environmental Science minors or to students who have taken CSENV 202. Offered fall semester only.
- CSENV 405, 605 Plant Breeding 3(2,2)** Application of genetic principles to the development of improved crop plants. Principal topics include the genetic and cytogenetic basis of plant breeding, mode of reproduction, techniques in selfing and crossing, methods of breeding, inheritance in the major crops, and biometrical methods. Offered spring semester only. *Preq:* GEN 302 or equivalent.
- CSENV 406 Special Problems 1-3(0,3-9)** Acquaints students with the scientific method. Literature investigation, planning, and execution of an experiment are integral parts of the course. Not open to AGRIC H491 and H492 students. May be repeated for a maximum of six credits. *Preq:* Senior standing, minor in Crop and Soil Environmental Science, and consent of department chair.
- CSENV 407, H407, 607 Introductory Weed Science 3(2,2)** Weed management in crops and pastures of the Southeast. Topics include weed identification, herbicide families and modes of action, herbicide formulations, herbicide diagnosis on crops and weeds, sprayer calibration and spray application, and nonchemical weed control strategies. *Preq:* AGRIC 104 or consent of instructor.