SCHOOL OF COMPUTING AND ENGINEERING

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Dean:
Kevin Z. Truman

Associate Dean of Faculty & Research
Masud Chowdhury

Department of Civil and Mechanical Engineering:
Chair:
352 Flarsheim Hall
(816) 235-5550

See CME Catalog (http://catalog.umkc.edu/colleges-schools/computing-engineering-school-of/civil-engineering-mechanical-engineering-department) and CME Website (http://sce.umkc.edu/cme)

Department of Computer Science Electrical Engineering:
Chair:
Ghulam M. Chaudhry
546 Flarsheim Hall
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See CSEE Catalog (http://catalog.umkc.edu/colleges-schools/computing-engineering-school-of/computer-science-electrical-engineering) and CSEE Website (http://sce.umkc.edu/about/computer-science-electrical-engineering)

History
The University has offered engineering degree programs since 1956. Increased technology demands during the mid-80s, combined with a generous gift from United Telecom (now Sprint), led to the development of UMKC's high-tech Computer Science and Telecommunications Program in 1984. These programs were combined in 2001 to form the School of Computing and Engineering (SCE).

Mission
The mission of the School of Computing and Engineering is to provide competitive educational opportunities and focused research in computing and engineering generating the technical workforce and research needed for economic development.

Departments and Degree Programs
The School of Computing and Engineering has two departments:

- Civil and Mechanical Engineering (http://www.sce.umkc.edu/cme)
- Computer Science Electrical Engineering (http://sce.umkc.edu/about/computer-science-electrical-engineering)

Each department offers undergraduate and graduate degrees. The Civil and Mechanical Engineering Department offers B.S. in Civil Engineering, B.S. in Mechanical Engineering – both accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org, M.S. in Civil Engineering,

The School also participates in UMKC’s Interdisciplinary Ph.D. program through four disciplines: computer science, electrical and computer engineering, engineering (for civil and mechanical engineering) and telecommunications and computer networking. (See the School of Graduate Studies section of this catalog for details about the Interdisciplinary Ph.D. Program.)

Financial Assistance

The University has several financial aid programs, scholarships and awards for the benefit of our students: see https://finaid.umkc.edu/ for opportunities available to all UMKC students. There are several School of Computing and Engineering scholarships available exclusively for SCE students. To be eligible, applicants must be accepted to both UMKC and and SCE degree program. All award recipients must maintain full-time student enrollment (minimum 12 credit hours/semester for undergraduate; 9 credit hours/semester per graduate) throughout the academic year of the award.

Applications are due by March 1 for full consideration for the next fall semester’s scholarship awards; however applications are accepted and kept on file year-round should additional awards become available. Current SCE scholarship recipients must re-apply each year by March 1 to be considered for the next academic year. More information about the scholarship process is available at https://sce.umkc.edu/affordability.

The Dean’s International Scholar Award (DISA) is available to SCE international students.

DISA awards are determined upon admission; therefore, no specific application form is required. Students must maintain at least a 3.0 GPA and remain in good standing to continue to receive the DISA.

Assistantships

There are Graduate Research Assistantships available through various faculty conducting funded research, and information on these can be obtained from individual faculty. Most faculty with funded research programs will award research assistantships to students whose performance they have been able to observe in the class room.

A limited number of graduate assistantships are available to fully-enrolled graduate students with excellent academic performance and solid communications skills.

Applications are available through the academic departments.

Faculty

Department of Civil and Mechanical Engineering

Katherine H. Bloemker; associate teaching professor; B.S., M.S. (Stanford University); Ph.D. (University of Missouri-Kansas City)

ZhiQiang Chen\textsuperscript{2,3}; associate professor; B.S. (Southeast University, Nanjing, China); M.S. Michigan Technological University); Ph.D. (University of California-San Diego).

Travis Fields\textsuperscript{2,3}; assistant professor; B.S., M.S., Ph.D. (University of Nevada, Reno).

Ceki Halmen\textsuperscript{2,3}; assistant professor; B.S. (Bogazici University, Istanbul, Turkey); M.S., Ph.D. (Texas A&M University).

Megan Hart; assistant professor; B.S. (Western Washington University), B.S., M.S., Ph.D. (Missouri University of Science and Technology); R.G.

John T. Kevern\textsuperscript{2,3}; associate professor; B.S. (University of Wisconsin-Platteville); M.S., Ph.D. (Iowa State University); LEED AP.

Greg King\textsuperscript{2,3}; associate professor; B.S., M.S., Ph.D. (University of Kansas).

Mark F. McClernon; associate professor; B.S. (Rockhurst University); M.S., Ph.D. (University of Notre Dame); P.E.

Amirfarhang Mehdizadeh\textsuperscript{2,3}; assistant professor; B.S. (University of Tehran, Iran); M.S., Dr.Ing. (Darmstadt University of Technology, Germany)

Deborah J. O’Bannon\textsuperscript{2,3}; professor; B.S. (Massachusetts Institute of Technology); M.Eng. (Manhattan College); Ph.D. (University of Iowa); P.E.

Jerry E. Richardson\textsuperscript{2,3}; associate professor; B.S., M.S., Ph.D. (Colorado State University); P.E.

Mary Cristina Ruales Ortega; associate teaching professor; B.S. (Universidad del Valle, Colombia); M.S. (University of Puerto Rico); Ph.D. (Florida International University)

William E. Stewart, Jr.; professor emeritus; B.S., M.S., Ph.D. (University of Missouri-Rolla); P.E. (Retired).
Antonis Stylianou; assistant professor; B.S., M.S., Ph.D. (University of Kansas).

Ganesh Thiagarajan^2^3; professor; B.Tech., M.Tech. (Indian Institute of Technology-Madras); Ph.D. (Louisiana State University-Baton Rouge).

Kevin Z. Truman^2^3; dean, professor, School of Computing & Engineering, B.A. (Monmouth College); B.S., M.S. (Washington University); Ph.D. (University of Missouri-Rolla).

**Department of Computer Science and Electrical Engineering**

Cory Beard^2^3; associate professor; B.S., M.S. (University of Missouri-Columbia); Ph.D. (University of Kansas).

Deb Chatterjee^2^3; associate professor; B.E.Tel.E. (Jadavpur University, India); M.Tech. (India Institute of Technology-Kharagpur, India); M.A.Sc. (Concordia University, Canada); Ph.D. (University of Kansas).

Ghulam M. Chaudhry^2^3; chair, dept. of computer science electrical engineering; professor; B.S. (University of Punjab, Pakistan); M.S. (B.Z. University, Pakistan); M.S., Ph.D. (Wayne State University).

Baek-Young Choi^2^3; associate professor; B.S. (Pusan National University, Korea); M.S. (Pohang University of Science and Technology, Korea); Ph.D. (University of Minnesota).

Masud H. Chowdhury^2^3; associate professor; B.S. (Bangladesh U. of Engineering & Technology, Dhaka 1000, Bangladesh); Ph.D. (Northwestern University).

Reza Derakhshani^2^3; associate professor; B.S. (Iran University of Science and Technology); M.S., Ph.D. (West Virginia University).

Deendayal "Dinakar" Dinakarpandian^2^3; associate professor; M.D. (Jawaharlal Institute of Post-Graduate Medical Education and Research, Pondicherry, India); Ph.D. (Case Western Reserve University); M.S. (University of Missouri-Kansas City).

Preetham Goli; assistant teaching professor; B.Tech (Andhra University, India), Ph.D. (University of Houston)

Yijie Han^2^3; associate professor; B.S. (University of Science and Technology of China), Ph.D. (Duke University).

Brian Hare; associate teaching professor; M.S. (University of Houston and University of Missouri-Kansas City).

Lein Harn^2^3; professor; B.A. (National Taiwan University); M.S. (University of New York at Stony Brook), Ph.D. (University of Minnesota).

Ahmed M. Hassan^2^3; assistant professor; B.S., M.S. (Cairo University); Ph.D. (University of Arkansas)

Richard G. Hetherington; founding director, computer science program, and professor emeritus; B.A. (Brothers College, Drew University); M.S., Ph.D. (University of Wisconsin-Madison).

Faisal Khan^2^3; associate professor; B.S. (Bangladesh University of Engineering and Technology); M.S. (Arizona State University); Ph.D. (University of Tennessee, Knoxville)

Kevin Kirkpatrick; associate teaching professor; B.S. (University of Missouri-Rolla); M.S. (University of Missouri - Columbia).

Jerome Knopp; associate professor; B.S., M.S., Ph.D. (University of Texas-Austin).

Mohammad Kuhail; assistant teaching professor; B.S., (Islamic University of Gaza); M.S. (University of York, York, UK); Ph.D. (University of Copenhagen).

Vijay Kumar^2^3; professor; B.S., M.S. (Ranchi University); Graduate Dipl. (Cambridge University); M.S. (Manchester University); Ph.D. (Southampton University).

Yugyung Lee^2^3; professor; B.S. (University of Washington); Ph.D. (New Jersey Institute of Technology).

Zhu Li^2^3; associate professor; B.S. (Sichuan University, China); M.S. (University of Louisiana-Lafayette) Ph.D. (Northwestern University)

Deepankar (Deep) Medhi^2^3; curators' professor; B.Sc. (Cotton College, Gauhati University); M.Sc. (University of Delhi); M.S., Ph.D. (University of Wisconsin-Madison).

Ken Mitchell^2^3; associate professor; B.M., M.M. (Indiana University); M.S., Ph.D. (University of Missouri-Kansas City).

Mostafizur Rahman^2^3; assistant professor; B.S. (North South University, Bangladesh); Ph.D. (University of Massachusetts-Amherst)

Praveen Rao^2^3; associate professor; B.Tech (University of Pune, India); M.S., Ph.D. University of Arizona-Tucson).

Xiaojun Shen^2^3; professor; B.S. (Quinghua University); M.S. (East China Institute of Technology); Ph.D. (University of Illinois-Urbana).
David G. Skitek; assistant professor emeritus; B.S. (University of Missouri-Rolla); M.S.E., Ph.D. (Arizona State University); P.E. (Retired)

Sejung Song^{2,3}; associate professor; B.S. (Pusan National University, Korea); M.S., Ph.D. (University of Minnesota - Twin Cities).

Appie van de Lievoort^{2,3}; professor; Kandidaats; Doctorandus (Katholieke Universiteit, Nijmegen, The Netherlands); M.S., Ph.D. (University of Nebraska-Lincoln).

Yongjie Zheng^{2,3}; assistant professor; B. Eng. (Tsinghua University, Beijing, China); M. Phil. (The Hong Kong Polytechnic University, Hong Kong); Ph.D. (University of California, Irvine).

1. Associate or Adjunct Graduate Faculty
2. Members of UMKC Graduate Faculty
3. Members of UMKC Doctoral Faculty
4. Located at UM-St. Louis campus

Civil Engineering Courses

CIV-ENGR 111 First Year Cornerstone Credits: 3
An exploration of the diverse emphasis specific career opportunities of Civil Engineers, with a goal of providing students the needed fundamental skills, knowledge and resources for identifying the most appropriate career path(s) consistent with the student’s interests, skills, and objectives.

CIV-ENGR 190 Special Topics Credits: 1-3
Selected introductory topics in the area of computing. May be repeated for credit when topic varies.

CIV-ENGR 211 The Engineering Enterprise Credits: 3
The engineering enterprise course covers the essential topic of engineering economics for engineering students. The primary objective of this course is to motivate the student to think as a blend of an engineer and a businessperson to make them more effective decision makers related to engineering applications.

CIV-ENGR 275 Engineering Statics Credits: 3
Fundamentals of statics; static equilibrium; internal forces; introduction to elements of mechanics of elastic materials, and properties of areas.
Prerequisites: PHYSICS 240.

CIV-ENGR 276 Strength Of Materials Credits: 3
The course introduces and emphasizes the concepts and analysis methods for stress and strain, torsion, bending and shear stresses in beams, combined stresses, and deflection theory using a calculus based methodology. Introduction to buckling and energy methods may be included.
Prerequisites: CIV-ENGR 275.

CIV-ENGR 318 GIS for Engineers Credits: 3
This course covers the fundamental concepts and methods for use of GIS software used to solve engineering applications and problems. The course uses module based practical learning to apply and integrate foundational knowledge, develop the skills required to model various types of imagery data, incorporate this data into projects for management and design, and provide the skills necessary for students to depict ideas and design graphically. A personal computer capable of running the software is required for the course. Non-engineering majors by instructor permission only.
Prerequisites: MEC-ENGR 130 and CIV-ENGR 319.

CIV-ENGR 319 Engineering Computation and Statistics Credits: 3
A review of descriptive statistics, statistical distribution functions and application to engineering problems. Introduction to hypothesis testing, analysis of variance, correlation/regression and design of factorial experiments.
Prerequisites: MEC-ENGR 219 (or corequisite), and MATH 268.

CIV-ENGR 320 Introduction to Factorial Design Credit: 1
Concepts and techniques of ANOVA and factorial design to supplement standard undergraduate statistics courses. Recommended preparation: Undergraduate statistics course.

CIV-ENGR 321 Structural Analysis Credits: 4
This course introduces the basic analysis and computer methods that are required to analyze basic structural elements and simple structures. Topics covered in this course include design loads, analysis of statically determinate beams, frames and trusses, shear and moment diagrams, influence diagrams, beam deflections, statically indeterminate structures (beams and frames), displacement methods, introduction to energy and matrix methods.
Prerequisites: CIV-ENGR 276.

CIV-ENGR 323 Structural Steel Design Credits: 3
Basic principles of structural steel design. Design of beams, axially loaded members, columns, and bolted and welded connections.
Prerequisites: CIV-ENGR 321.
CIV-ENGR 335 Soil Mechanics Credits: 3
Detailed study of physical and mechanical properties of soil governing its behavior as an engineering material.
Prerequisites: CIV-ENGR 276, CHEM 211, CHEM 211L, Machine Shop Safety.

CIV-ENGR 342 Water and Wastewater Treatment Processes Credits: 3
Methods for determining and characterizing water quality, effects of pollution on streams and lakes, and an introduction to engineering systems for the distribution, collection and treatment of water and wastewater.
Prerequisites: CIV-ENGR 351, CHEM 211 and CHEM 211L.

CIV-ENGR 351 Fluid Mechanics Credits: 3
Concepts of the statics and dynamics of fluids, with emphasis on principles of continuity, momentum and energy. Boundary layers, dimensional analysis and drag are covered briefly. Thorough treatment of pipe flow.
Prerequisites: MATH 345 or MEC-ENGR 272, MEC-ENGR 285.

CIV-ENGR 357 Engineering Hydraulics Credits: 3
Analysis and design of closed conduit systems for water supply; fundamentals of open channel flow; principles of pumping and hydropower generation; transients and control of surge pressures in pipelines.
Prerequisites: CIV-ENGR 351.

CIV-ENGR 378WI Civil Engineering Materials Credits: 3
This course provides students with a working knowledge of the design and performance of Asphaltic Concrete (AC) and Portland Cement Concrete (PCC) mixtures through understanding the properties and requirements of the component materials and their effects on subsequent performance. An understanding of the design, production process, construction, durability, and operations and maintenance will be provided. A significant portion of this course requires hands-on laboratory testing and analysis. Roadway and highway pavements will provide a primary context within which these concrete systems will be studied.
Prerequisites: CHEM 211, CHEM 211L, CIV-ENGR 276, Machine Shop Safety, RooWriter.

CIV-ENGR 390 Engineering Coop/Internship Credits: 0
Students may participate in structured Engineering Coop/Internship under the supervision of employer. They must carry out significant professional responsibilities and whatever additional assignments are determined by the employer.
Prerequisites: CIV-ENGR 211, MEC-ENGR 285.

CIV-ENGR 3EP UL Civil Engineering Elective Credits: 99
Transfer credit

CIV-ENGR 400 Problems Credits: 1-4
Directed investigation of civil engineering problems.

CIV-ENGR 401ES Special Topics in Civil Engineering Credits: 3
Prerequisites: CIV-ENGR 335.

CIV-ENGR 401HA Hydrologic Analysis and Design Credits: 3
Practical implementation of hydrologic and hydraulic system design in accordance with published design criteria and using methods and numerical modeling accepted by local, state, and national government agencies.
Prerequisites: CIV-ENGR 357.

CIV-ENGR 401J Project Finance Credits: 1-3
Students will learn how to read and apply financial statements and how to use these same financial concepts in developing pro formas to evaluate and support major capital investments. The effect of time on the value of money, appropriate discount factors, and the internal rate of return will be explored in the class. Students will learn to combine these financial factors with electronic spreadsheets to evaluate business opportunities and practices. All students will be required to develop a comprehensive financial model to evaluate/justify a real world capital project.

CIV-ENGR 401PM Project Management of Integrated Design and Construction Credits: 3
Provide a body of knowledge that includes the principles, knowledge areas, skills, and tools applicable to successful project management for the performance of integrated design and construction of capital projects, specifically as applicable to the post-award period. This post-award period is the time from the formal Project award by the owner through Project design and construction, testing, commissioning, close-out and completion of the Project warranties.

CIV-ENGR 401SD Special Topics In Civil Engineering Credits: 3
Study of soil behavior under cyclic and dynamic loading conditions. Foundation design for vibratory loadings. Introductory earthquake engineering including dynamic ground response for determination of dynamic soil properties. Evaluation of soil liquefaction potential during earthquakes by both laboratory and in situ filed methods. Design consideration for embankments and earth retaining structures under seismic loading conditions. Construction blasting and vibration effects on underground systems.
Prerequisites: CIV-ENGR 335.
CIV-ENGR 401SV Topics in Civil Engineering Credit: 1
This course provides a fundamental introduction to the elements of surveying. Basics including terminology, coordinate systems, equipment, legal descriptions, and calculations will be taught in the classroom. Field laboratory sessions will introduce the students to setting up basic equipment, running a level loop, and laying out a site based on plan designs.

CIV-ENGR 404 Project Management of Integrated Design and Construction Credits: 3
Provide a body of knowledge that includes the principles, knowledge areas, skills, and tools applicable to successful project management for the performance of integrated design and construction of capital projects, specifically as applicable to the post-award period. This post-award period is the time from the formal project award by the owner through project design and construction, testing, commissioning, close-out and completion of the project warranties.

CIV-ENGR 405 Capital Project Delivery Methods Credits: 3
Provide a body of knowledge that acquaints students with the capital project delivery methods in both public and private business sectors of the U.S design – construction industry. Project delivery means how a capital project comprising both design and construction is planned, procured, contracted and implemented by an owner to achieve desired objectives. Delivery methods discussed in this class include traditional design – build, design – build, design-build plus added services such as operations and maintenance, CM @ Risk and other approaches. Roles and responsibilities of owners, owner consultants, and design and construction firms are presented and discussed.

CIV-ENGR 409 Fundamentals of Engineering Review Credit: 1
This course consists of a series of lectures and is intended as a review class for all the subjects included in the Fundamentals of Engineering exam. Classes specifically focus on the review of equations and formulas included in the reference handbook published by NCEES.

CIV-ENGR 411 Civil Engineering Systems Design I Credits: 2
Comprehensive and realistic design project using the systems approach. Design choices and their effect upon the environment. Design constraints include constructability, minimization of environmental impact and cost-effectiveness. Managerial and professional aspects of design practice.

Prerequisites: CIV-ENGR 497.

Co-requisite: CIV-ENGR 422WI.

CIV-ENGR 412 Civil Engineering Systems Design II Credits: 3
Continuation of CIV-ENGR 411.

Prerequisites: CIV-ENGR 411, RooWriter.

CIV-ENGR 415 Engineering Leadership and Ethics Credits: 3
Analysis of leadership, including 360-degree assessment of students’ leadership. Discussion of leadership cases and application to engineering careers. Frequent analysis of engineering ethics cases using the NSPE Code.

CIV-ENGR 421 Matrix Methods of Structural Analysis Credits: 3
The basic components of this class are matrix theories and applied computer analysis methods using a computer-based structural analysis software. These include: (1) study of matrix formulation of direct stiffness method, virtual work principle and formulation of displacement-based frame elements, theories and significance of geometric and material nonlinearity; (2) Sap2000-based analysis of 2D/3D trusses and 2D/3D frames considering different loading and material/geometric nonlinearity.

Prerequisites: CIV-ENGR 321.

CIV-ENGR 422WI Reinforced Concrete Design Credits: 3
Basic principles of reinforced concrete design. Design of beams for flexure and shear; design of short and slender columns. Bond stress development. Footing design.

Prerequisites: CIV-ENGR 321, RooWriter.

CIV-ENGR 423 Advanced Structural Steel Design Credits: 3
Design of steel structures and bridges. Topics include composite beams, plate girder design, and moment resistant connections.

Prerequisites: CIV-ENGR 323.

CIV-ENGR 425 Prestressed Concrete Credits: 3
Design and behavior of prestressed concrete structures; material and system of pretensioned and post tensioned systems; prestress losses; flexure, shear, bond, deflections and partial prestress in determinate structures; indeterminate beams-introduction.

Prerequisites: CIV-ENGR 422WI.

CIV-ENGR 427 Advanced Reinforced Concrete Design Credits: 3
Advanced topics in the design of footings, retaining walls, two-way floor slabs, torsion and continuous structures, shear friction, strut and tie design, precast design.

Prerequisites: CIV-ENGR 422WI.

CIV-ENGR 429 Design of Structures for Blast and Fire Credits: 3
General overview of Blast Design; risk assessment and design criteria; simplifies Blast Effects Analysis; ground shock, material response; antiterrorism design considerations; weapons effects and mitigation; internal explosions; progressive collapse analysis; and introduction to Fire Design.
CIV-ENGR 431 Fundamentals of Geomaterial Characterization Credits: 3
A geomaterial is any construction material comprised primarily of soil. This course overviews state-of-the-art instrumental techniques for analysis of the physio-chemical properties of soils, aggregates, hydraulic concrete, and asphaltic concrete. Evaluation techniques will be applied to determining beneficial reuse opportunities for industrial by-product materials from the Kansas City region.

**Prerequisites:** CIV-ENGR 335, CIV-ENGR 378WI.

CIV-ENGR 432 Foundation Engineering Credits: 3
Design of basic foundation structures, footings, retaining walls, pile foundations, dams.

**Prerequisites:** CIV-ENGR 335.

CIV-ENGR 436 Advanced Soil Mechanics Credits: 3
Theoretical soil mechanics as applied to solution of specific engineering problems.

**Prerequisites:** CIV-ENGR 335.

CIV-ENGR 442 Hydraulic Structures Credits: 3
A review of the history and hydraulic design procedures for a variety of hydraulic structures including spillways, water measurement structures, canal structures and energy dissipation structures.

**Prerequisites:** CIV-ENGR 452.

CIV-ENGR 446 Limnology Credits: 3
Physical, biological and chemical issues important in surface fresh waters. Includes carbonate chemistry, algal assay and thermocline analysis.

**Prerequisites:** CHEM 211, MATH 345.

CIV-ENGR 447 Contracts and Law for Engineers Credits: 3
This course covers a broad range of substantive legal topics giving the student a grounding in the legal implications of certain situations that they may encounter during their careers. The course includes coverage of basic contract law, environmental regulations and compliance, construction law, antitrust law, intellectual property law, civil procedure, employment law, business entities (corporate law) product liability and criminal law and procedure. The objective of the course is to provide students with a fundamental understanding of the wide range of federal and state laws governing behavior in our complicated and rule of law driven society.

CIV-ENGR 449 Environmental Compliance, Auditing and Permitting Credits: 3
This course provides a high level overview of the most important statutes that have been enacted to protect the environment. The course covers regulation of hazardous waste, the Clean Air and Clean Water Acts, the Resource Conservation and Recovery Act, the All Appropriate Inquiry Rule and the law addressing sites contaminated with hazardous substances and the technology options employed to remediate those sites. In addition, the course provides coverage of environmental audits and emergency planning for extremely hazardous substances, the regulation of underground storage tanks, safe drinking water and the National Environmental Policy Act among other statutes.

CIV-ENGR 452 Hydraulics of Open Channels Credits: 3
This is a first course in the fundamentals of open channel (free surface) water flow. Over ninety-nine percent of all the water that is moved on the planet's surface is by free surface flow. Study of free surface flow is essential to the study of storm water drainage systems, flood control, water and wastewater treatment and the study of the form and processes of river evolution. This class provides the fundamental physical principles of free surface flow as a prelude to a significant number of other topics that pertain to engineering and geomorphic analysis.

**Prerequisites:** CIV-ENGR 351.

CIV-ENGR 453 Hydraulics and Variability of Rivers Credits: 3
Introduction to the concepts of alluvial channel behavior, evolution and change due to natural and man-induced modifications to streams and watersheds. Numerous case studies of river behavior are studied from the perspective of hydraulics, geomorphology and sediment transport.

**Prerequisites:** CIV-ENGR 357.

CIV-ENGR 454 River Stability and Scour Credits: 3
Bridge hydraulics, stream stability, scour at bridge piers and abutments, hydraulic modeling of floods, countermeasures for protection of bridge infrastructure.

**Prerequisites:** CIV-ENGR 452.

CIV-ENGR 456 Urban Hydrology Credits: 3
Analysis of urban drainage systems in accordance with published municipal criteria. This course is an in-depth course for senior undergraduate students interested in the hydrological sciences and for graduate students specializing in water resources. Specifically this course will focus on the engineering procedures and techniques specified by municipalities to design and maintain efficient, safe, storm drainage systems. This course also focuses on the unique issues associated with estimating and designing for rainfall/runoff in urban metropolitan areas, including channel and reservoir routing of floods through stream channels, retention structures, culverts, and storm sewers.

**Prerequisites:** CIV-ENGR 357.
CIV-ENGR 463 The Engineer in Society Credits: 3
This course introduces professional, ethical, and legal concepts of the professional practice of engineering, and the role of the consulting engineer, specifically in the A/E/C industry during the design, procurement, and construction processes. A conceptual framework is developed for understanding the industry standard agreements (AIA, EJCDC, ConCensus) and the various participants roles and duties in project execution. The engineer’s “professional standard of care” is examined and revisited throughout the semester, specifically what it means to be a “Professional Engineer”. Emphasis is placed on project and contract management and the applicable law.

CIV-ENGR 466 Green Building and Sustainable Infrastructure Credits: 3
This class will discuss various green rating systems for buildings and infrastructure. Upon completion of this course students will be prepared for the LEED Green Associate Exam. The course will also discuss infrastructure project sustainability from a life cycle perspective. A semester project will involve stormwater management using "green" techniques and methods to mitigate the urban heat island. Upon completion of the course, students will better understand what sustainability means and how it applies in the context of our built environment and have a good idea of how technology will impact our sustainable future.

Prerequisites: Junior standing.

CIV-ENGR 467 Introduction to Construction Management Credits: 3
Structure of the construction industry; construction drawings and specifications; estimating and bidding; construction contracts, bonds and insurance; planning and scheduling of construction operations; project management; computer techniques.

Prerequisites: MATH 345.

CIV-ENGR 468 Construction Planning and Scheduling Credits: 3
This course is intended to provide an in-depth examination of the construction planning and scheduling process, as it relates to civil engineering projects. Topics will include planning and scheduling of construction operations by the critical path method, Network diagramming, scheduling computations, and time-cost trade-offs. Manpower and equipment leveling. Computer and noncomputer techniques.

Prerequisites: CIV-ENGR 467.

CIV-ENGR 469 Construction Methods and Equipment Credits: 3
Introduction to methods used to plan, construct, and manage heavy civil projects. Topics will include development, project control, equipment productivity, earthmoving fundamentals, formwork design, and other issues in heavy civil projects.

Prerequisite: CIV-ENGR 467.

CIV-ENGR 470 Corrosion Engineering Credits: 3
This course will cover the physical interaction of metallic materials with their environments, called corrosion. Corrosion is an electrochemical process and the thermodynamics and kinetics of corrosion processes will be discussed. Students will be expected to identify different forms of corrosion and be able to select appropriate materials for their working environment to prevent corrosion related problems. Second half of the class will concentrate on corrosion of metals in concrete and prevention methods.

Prerequisites: CHEM 211, CHEM 211L, CIV-ENGR 378WI.

CIV-ENGR 471 Advanced Portland Cement Concrete Credits: 3
This course will cover topics such as cement chemistry, concrete proportioning, aggregates, mineral and chemical admixtures, fresh and hardened properties of concrete, and durability of concrete. Design and proportioning of concrete mixtures for desired fresh and hardened properties will be emphasized. Specialty concrete types such as high strength/high performance concrete, lightweight concrete, pervious concrete, high volume fly ash concrete, and fiber reinforced concrete will also be covered.

Prerequisites: CHEM 211, CHEM 211L, CIV-ENGR 378WI.

CIV-ENGR 473 Durability of Civil Engineering Materials Credits: 3
This course will explore the identification, causes of, and remediation of material-related durability deterioration in civil engineering projects. The primary focus will be on reinforced concrete, plain concrete, and soil for a variety of applications. Course content will be delivered primarily through laboratory activities and handouts. Lab activities will use advanced analysis techniques and help the students identify and measure deterioration mechanisms. Various non-destructive evaluation techniques will be discussed. Students have hands on experiences with samples production, data collection, and data analysis for all of the lab activities.

Prerequisites: CIV-ENGR 335, CIV-ENGR 378WI.

CIV-ENGR 475 Seismic Design of Structures Credits: 3
Introduction to basic analysis and design principles for the seismic design of buildings (concrete, steel, wood). General seismic principles, codes and loads, static lateral force procedure, dynamic lateral force procedure, topics in rigidities of buildings.

Prerequisites: CIV-ENGR 323 (or CIV-ENGR 422WI), MEC-ENGR 285.

CIV-ENGR 481 Highway and Traffic Engineering Credits: 3
Principles of highway engineering and traffic analysis, road/vehicle performance, geometric alignment of highways, traffic analysis and queuing theory, signal design, statistical analysis of traffic data and highway drainage.

Prerequisites: MEC-ENGR 285.
CIV-ENGR 484 Pavement Materials Design, Maintenance, and Rehabilitation Credits: 3
Traffic loading and volume, stress and deflection, characterization of pavement materials, design of flexible and rigid pavements, design of overlays, evaluation of pavement performance, maintenance techniques, and rehabilitation options.
Prerequisites: CIV-ENGR 335, CIV-ENGR 378WI.

CIV-ENGR 487 Applied Finite Element Analysis Credits: 3
The study of advanced simulation techniques for the solution to engineering problems. The use of Finite Element Method toward solving mechanical, structural, vibration and potential flow problems will be explored. Current commercial simulation tools will be used extensively.
Prerequisites: MEC-ENGR 272 and MEC-ENGR 130.

CIV-ENGR 491 Internship Credits: 6
For International students who must register to cover off-campus employment which is approved as related to their degree by their departmental advisor and ISAO.

CIV-ENGR 497 Engineering Hydrology Credits: 3
Fundamental concepts of hydrology in engineering; computation principles of runoff from rainfall; measurement of hydrologic quantities; quantitative and statistical estimation of design stream-flow magnitude and frequency; principles of unsteady routing of hydrographs.
Prerequisites: CIV-ENGR 319, CIV-ENGR 351.

CIV-ENGR 5500 Problems Credits: 1-6
Supervised investigation in civil engineering to be presented in the form of a report.
Prerequisites: Graduate standing.

CIV-ENGR 5501 Advanced Topics in Civil Engineering Credits: 1-3
Current technical developments in civil engineering.

CIV-ENGR 5501AE Advanced Topics in Civil Engineering Credits: 1-3

CIV-ENGR 5501AS Advanced Topics in Civil Engineering Credits: 1-3

CIV-ENGR 5501CP Advanced Topics in Civil Engineering Credits: 1-3
Advanced Topics in Civil Engineering

CIV-ENGR 5501DM Advanced Topics in Civil Engineering - Capital Project Delivery Methods Credits: 1-3
Provide a body of knowledge that acquaints students with the capital project delivery methods in both public and private business sectors of the U.S. design – construction industry. Project delivery means how a capital project comprising both design and construction is planned, procured, contracted and implemented by an owner to achieve desired objectives. Delivery methods include traditional design – bid- build, design – build, design-build plus added services such as operations and maintenance, CM @ Risk and other approaches. Roles and responsibilities of owners, owner consultants, and design and construction firms are presented and discussed. Owner procurement approaches, project risk allocation, and how design and construction firms compete for projects will be examined. Students will contribute to and evaluate owner procurement documents such as requests for qualifications (RFQ) and requests for proposal (RFP).

CIV-ENGR 5501DS Advanced Topics in Civil Engineering Credits: 1-3

CIV-ENGR 5501ES Advanced Topics in Civil Engineering Credits: 1-3
Advanced Topics in Civil Engineering.
Prerequisites: CIV-ENGR 335.

CIV-ENGR 5501FM Advanced Topics in Civil Engineering Credits: 1-3
Advanced Topics in Civil Engineering

CIV-ENGR 5501G Advanced Topics in Civil Engineering Credits: 1-3

CIV-ENGR 5501GB Advanced Topics in Civil Engineering Credits: 1-3

CIV-ENGR 5501GS Advanced Topics in Civil Engineering Credits: 1-3

CIV-ENGR 5501HA Advanced Topics in Civil Engineering Credits: 3
Practical implementation of hydrologic and hydraulic system design in accordance with published design criteria and using methods and numerical modeling accepted by local, state, and national government agencies.
Prerequisites: CIV-ENGR 357.

CIV-ENGR 5501IR Adv Topics in Civil Engineering Credits: 1-3
Adv Topics in Civil Engineering
School of Computing and Engineering

CIV-ENGR 5501J Advanced Topics In Civil Engineering Credits: 1-3
This class introduces students to the financial concepts faced by engineers in the businesses in which they work and for the projects to which they are assigned. Throughout the course students are reminded of the impact of two key variables – money and time – on their work. While not attempting to turn good engineers into mediocre accountants, the course includes a strong emphasis on managerial accounting. Students will learn how to read and apply financial statements and how to use these same financial concepts in developing pro formas to evaluate and support major capital investments. The effect of time on the value of money, appropriate discount factors, and the internal rate of return will be explored in the class. Students will learn to combine these financial factors with electronic spreadsheets to evaluate business opportunities and practices. All students will be required to develop a comprehensive financial model to evaluate/justify a real world capital project.

CIV-ENGR 5501L Advanced Topics In Civil Engineering Credits: 1-3

CIV-ENGR 5501M Advanced Topics in Civil Engineering Credits: 1-3
Advanced Topics in Civil Engineering

CIV-ENGR 5501MD Advanced Topics in Civil Engineering Credits: 1-3
Advanced Topics in Civil Engineering

CIV-ENGR 5501MM Advanced Topics in Civil Engineering Credits: 1-3
Advanced Topics in Civil Engineering

CIV-ENGR 5501MX Advanced Topics in Civil Engineering Credits: 1-3
Advanced Topics in Civil Engineering

CIV-ENGR 5501PM Advanced Project Management of Integrated Design and Construction Credits: 3
Provide a body of knowledge that includes the principles, knowledge areas, skills, and tools applicable to successful project management for the performance of integrated design and construction of capital projects, specifically as applicable to the post-award period. This post-award period is the time from the formal Project award by the owner through Project design and construction, testing, commissioning, close-out and completion of the Project warranties.

CIV-ENGR 5501S Advanced Topics In Civil Engineering Credits: 1-3

CIV-ENGR 5501SD Advanced Topics in Civil Engineering Credits: 3
Study of soil behavior under cyclic and dynamic loading conditions. Foundation design for vibratory loadings. Introductory earthquake engineering including dynamic ground response for determination of dynamic soil properties. Evaluation of soil liquefaction potential during earthquakes by both laboratory and in situ filed methods. Design consideration for embankments and earth retaining structures under seismic loading conditions. Construction blasting and vibration effects on underground systems.
Prerequisites: CIV-ENGR 335.

CIV-ENGR 5501SP Advanced Topics In Civil Engineering Credits: 1-3

CIV-ENGR 5501SW Advanced Topics in Civil Engineering Credits: 1-3

CIV-ENGR 5504 Project Management of Integrated Design and Construction Credits: 3
Provide a body of knowledge that includes the principles, knowledge areas, skills, and tools applicable to successful project management for the performance of integrated design and construction of capital projects, specifically as applicable to the post-award period. This post-award period is the time from the formal Project award by the owner through Project design and construction, testing, commissioning, close-out and completion of the Project warranties.

CIV-ENGR 5505 Capital Project Delivery Methods Credits: 3
Provide a body of knowledge that acquaints students with the capital project delivery methods in both public and private business sectors of the U.S design – construction industry. Project delivery means how a capital project comprising both design and construction is planned, procured, contracted and implemented by an owner to achieve desired objectives. Delivery methods include traditional design – bid- build, design – build, design-build plus added services such as operations and maintenance, CM @ Risk and other approaches. Roles and responsibilities of owners, owner consultants, and design and construction firms are presented and discussed. Owner procurement approaches, project risk.

CIV-ENGR 5515 Engineering Leadership & Ethics Credits: 3
Analysis of leadership, including 360-degree assessment of students’ leadership. Discussion of leadership cases and application to engineering careers. Frequent analysis of engineering ethics cases using the NSPE Code.
Prerequisites: Graduate status.

Cross Listings: CIV-ENGR 415.

CIV-ENGR 5521 Matrix Methods of Structural Analysis Credits: 3
An introduction to the fundamentals of stiffness and flexibility methods for analysis of truss and frame structures. Application of the computer programs to three dimensional structures.
Prerequisites: CIV-ENGR 321.

Cross Listings: CIV-ENGR 421.
CIV-ENGR 5523 Advanced Structural Steel Design Credits: 3
Design of steel building structures. Topics include composite deck and beam design, stability design, plastic design, plate girder design, simple and eccentric shear connections, and partial and fully restrained moment resistant connections.
Prerequisites: CIV-ENGR 323.

CIV-ENGR 5526 Prestressed Concrete Credits: 3
Design and behavior of prestressed concrete structures; material and system or pretensioned and post tensioned systems; prestress losses; flexure, shear, bond, deflections and partial prestress in determinate structures; indeterminate beams-introduction.
Prerequisites: CIV-ENGR 422WI.

CIV-ENGR 5527 Advanced Reinforced Concrete Design Credits: 3
Advanced Topics in the design of footings, retaining walls two way floor slabs, torsion and continuous structures, shear friction, strut and tie design, precast design.
Prerequisites: CIV-ENGR 422WI.

Cross Listings: CIV-ENGR 427.

CIV-ENGR 5529 Advanced Design of Structures for Blast and Fire Credits: 3
General overview of Blast Design; risk assessment and design criteria; simplified Blast Effects Analysis; ground shock, material response; antiterrorism design considerations; weapons effects and mitigation; internal explosions; progressive collapse analysis; and introduction to Fire Design.

CIV-ENGR 5531 Fund of Geomaterial Characterization Credits: 3
A geomaterial is any construction material comprised primarily of soil. This course overviews state-of-the-art instrumental techniques for analysis of the physio-chemical properties of soils, aggregates, hydraulic concrete, and asphaltic concrete. Evaluation techniques will be applied to determining beneficial reuse opportunities for industrial by-product materials from the Kansas City region. Prerequisites are CE 335 Soil Mechanics and CE378 Civil Engineering Materials, or equivalent. 3 credit hours.
Prerequisites: CIV-ENGR 335, CIV-ENGR 378WI.

CIV-ENGR 5532 Foundation Engineering Credits: 3
Design of basic foundation structures, footings, retaining walls, pile foundations, dams.
Prerequisites: CIV-ENGR 335.

Cross Listings: CIV-ENGR 432.

CIV-ENGR 5536 Advanced Soil Mechanics Credits: 3
Theoretical soil mechanics as applied to solution of specific engineering problems.
Prerequisites: CIV-ENGR 335.

Cross Listings: CIV-ENGR 436.

CIV-ENGR 5542 Hydraulic Structures Credits: 3
A review of the history and hydraulic design procedures for a variety of hydraulic structures including spillways, water measurement structures, canal structures and energy dissipation structures.
Prerequisites: CIV-ENGR 452 (or CIV-ENGR 5552).

CIV-ENGR 5544 Unit Processes in Environmental Engineering Credits: 3
Typical chemical and physical relationships are applied to unit processes of water and wastewater. Troubleshooting for operation problems is emphasized.
Prerequisites: CIV-ENGR 342.

CIV-ENGR 5545 Environmental Engineering Microbiology Credits: 3
Theory and application of fundamental principles of microbiology, toxicology, ecology, and aquatic biology of the microorganisms of importance to environmental engineers.
Prerequisites: CE342.

CIV-ENGR 5546 Limnology Credits: 3
A survey of the physical, biological, and chemical issues important in surface fresh waters. Includes carbonate chemistry, algal assay and Thermocline analysis.
Prerequisites: CHEM 211, MATH 345.
This course introduces the financial concepts faced by engineers in the businesses in which they work and for the projects to which they are assigned. Throughout the course students are reminded of the impact of two key variables – money and time – on their work. While not attempting to turn good engineers into mediocre accountants, the course includes a strong emphasis on managerial accounting. Students will learn how to read and apply financial statements and how to use these same financial concepts in developing pro formas to evaluate and support major capital investments. The effect of time on the value of money, appropriate discount factors, and the internal rate of return will be explored in the class. In addition, the course provides coverage of environmental audits and emergency planning for extremely hazardous substances, the regulation of underground storage tanks, safe drinking water and the National Environmental Policy Act among other statutes.

Prerequisites: ANCHOR 201/CIV-ENGR 211, MEC-ENGR 285.

Cross Listings: CIV-ENGR 449.

CIV-ENGR 5552 Hydraulics of Open Channels Credits: 3
This is a first course in the fundamentals of open channel (free surface) water flow. Over ninety-nine percent of all the water that is moved on the planet's surface is by free surface flow. Study of free surface flow is essential to the study of storm water drainage systems, flood control, water and wastewater treatment and the study of the form and processes of river evolution. This class provides the fundamental physical principles of free surface flow as a prelude to a significant number of other topics that pertain to engineering and geomorphic analysis.

Prerequisites: CIV-ENGR 351.

CIV-ENGR 5553 Hydraulics and Variability of Rivers Credits: 3
This course introduced concepts of alluvial channel behavior, evolution and change due to natural and man-induced modifications to streams and watersheds. Numerous case studies of river behavior are studied from the perspective of hydraulics, geomorphology and sediment transport.

Prerequisites: CIV-ENGR 357.

CIV-ENGR 5554 River Stability and Scour Credits: 3
Bridge hydraulics, stream stability, scour at bridge piers and abutments, hydraulic modeling of floods, countermeasures for protection of bridge infrastructure.

Prerequisites: CIV-ENGR 452 (or CIV-ENGR 5552).

Cross Listings: CIV-ENGR 454.

CIV-ENGR 5556 Urban Hydrology Credits: 3
Analysis of urban drainage systems in accordance with published municipal criteria. This course is an in-depth, follow on course for senior undergraduate students interested in the hydrological sciences and for graduate students specializing in water resources. Specifically this course will focus on the engineering procedures and techniques specified by municipalities to design and maintain efficient, safe, storm drainage systems. This course also focuses on the unique issues associated with estimating and designing for rainfall/runoff in urban metropolitan areas, including channel and reservoir routing of floods through stream channels, retention structures, culverts, and storm sewers.

Prerequisites: CIV-ENGR 357.

CIV-ENGR 5563 Construction Law Credits: 3
This course introduces professional, ethical, and legal concepts of the professional practice of engineering, and the role of the consulting engineer, specifically in the A/E/C industry during the design, procurement, and construction processes. A conceptual framework is developed for understanding the industry standard agreements (AIA, EJCDC, ConCensus) and the various participants roles and duties in project execution. The engineer’s “professional standard of care” is examined and revisited throughout the semester, specifically what it means to be a “Professional Engineer”. Emphasis is placed on project and contract management and the applicable law. Skills are developed in finding online resources of law, legal, and practice advice relevant to the practice of engineering and the construction industry.

CIV-ENGR 5565 Project Finance Credits: 3
This class introduces students to the financial concepts faced by engineers in the businesses in which they work and for the projects to which they are assigned. Throughout the course students are reminded of the impact of two key variables – money and time – on their work. While not attempting to turn good engineers into mediocre accountants, the course includes a strong emphasis on managerial accounting. Students will learn how to read and apply financial statements and how to use these same financial concepts in developing pro formas to evaluate and support major capital investments. The effect of time on the value of money, appropriate discount factors, and the internal rate of return will be explored in the class. Students will learn to combine these financial factors with electronic spreadsheets to evaluate business opportunities and practices. All students will be required to develop a comprehensive financial model to evaluate/justify a real world capital project.
CIV-ENGR 5566 Green Building and Sustainable Infrastructure Credits: 3
This course provides a broad overview of what sustainability means to construction and our built environment. Specific green infrastructure rating systems of LEED and Envision will be discussed in detail to quantify the “greenness” of construction of buildings residential subdivisions, highways, roads, and airports. Upon completion of this course students will have a substantial background and understand the aspects needed for the LEED Green Associates and Envision ISI exams. Two major additional aspects of green building important to sustainable infrastructure include stormwater management using “green” techniques and methods to mitigate the urban heat island. The course will also discuss infrastructure project sustainability from a life cycle cost perspective and determining the life cycle inventory of various materials. Upon completion of the course, students will better understand what sustainability means and how it applies in the context of our built environment and have a good idea of how technology will impact our sustainable future.

Cross Listings: CIV-ENGR 466.

CIV-ENGR 5567 Introduction to Construction Management Credits: 3
This course will introduce the students to basic construction management related topics including structure of the construction industry, construction drawings and specifications, estimating and bidding, construction contracts, bonds and insurance, planning and scheduling of construction operations, project management, computer techniques.

Prerequisites: MEC-ENGR 272 (or MATH 345).

CIV-ENGR 5568 Construction Planning and Scheduling Credits: 3
This course is intended to provide an in-depth examination of the construction planning and scheduling process, as it relates to civil engineering projects. Topics will include planning and scheduling of construction operations by the critical path method, Network diagramming, scheduling computations, and time-cost trade-offs. Manpower and equipment leveling. Computer and noncomputer techniques.

Prerequisites: CIV-ENGR 467.

CIV-ENGR 5569 Construction Methods and Equipment Credits: 3
Introduction to methods used to plan, construct and manage heavy civil projects. Topics will include development, project control, equipment productivity, earthmoving fundamentals, formwork design, and other issues in heavy civil projects.

Prerequisites: CIV-ENGR 467.

CIV-ENGR 5570 Corrosion Engineering Credits: 3
This course will cover the physical interaction of metallic materials with their environments, called corrosion. Corrosion is an electrochemical process and the thermodynamics and kinetics of corrosion processes will be discussed. Students will be expected to identify different forms of corrosion and be able to select appropriate materials for their working environment to prevent corrosion related problems. Second half of the class will concentrate on corrosion of metals in concrete and prevention methods.

Prerequisites: CHEM 211, CHEM 211L, CIV-ENGR 378WI.

CIV-ENGR 5571 Advanced Portland Cement Concrete Credits: 3
This course will cover topics such as cement chemistry, concrete proportioning, aggregates, mineral and chemical admixtures, fresh and hardened properties of concrete, and durability of concrete. Design and proportioning of concrete mixtures for desired fresh and hardened properties will be emphasized. Specialty concrete types such as high strength/high performance concrete, lightweight concrete, pervious concrete, high volume fly ash concrete, and fiber reinforced concrete will also be covered.

Prerequisites: CHEM 211, CHEM 211L, CIV-ENGR 378WI.

CIV-ENGR 5573 Durability of Civil Engineering Materials Credits: 3
This course will explore the identification, causes of, and remediation of material-related durability deterioration in civil engineering projects. The primary focus will be on reinforced concrete, plain concrete, and soil for a variety of applications. Course content will be delivered primarily through laboratory activities and handouts. Lab activities will use advanced analysis techniques and help the students identify and measure deterioration mechanisms. Various non-destructive evaluation techniques will be discussed. Students have hands on experiences with samples production, data collection, and data analysis for all of the lab activities.

Prerequisites: CIV-ENGR 335, CIV-ENGR 378WI.

CIV-ENGR 5575 Seismic Design of Structures Credits: 3
Introduction to basic analysis and design principles for the seismic design of buildings (concrete, steel, wood). General seismic principles, codes and loads, static lateral force procedure, dynamic lateral force procedure, topics in rigidities of buildings.

Prerequisites: CIV-ENGR 323 (or CIV-ENGR 422WI), MEC-ENGR 285.

CIV-ENGR 5582 Advanced Traffic Engineering Credits: 3
This course covers the review of traffic flow characteristics, the field survey practices and studies, traffic signal designs, freeway operation, and the introduction to Intelligent Traffic Systems (ITS).

Prerequisites: CIV-ENGR 319, CIV-ENGR 481.
CIV-ENGR 5584 Pavement Materials, Design, Maintenance, and Rehabilitation Credits: 3
This course will explore the identification, causes of, and remediation of material-related durability deterioration in civil engineering projects. The primary focus will be on reinforced concrete, plain concrete, and soil for a variety of applications. Course content will be delivered primarily through laboratory activities and handouts. Lab activities will use advanced analysis techniques and help the students identify and measure deterioration mechanisms. Various non-destructive evaluation techniques will be discussed. Students have hands on experiences with samples production, data collection, and data analysis for all of the lab activities.
**Prerequisites:** CIV-ENGR 378WI.

CIV-ENGR 5585 Principles of Railroad Engineering Credits: 3
The engineering analysis and design of railroad systems including the study of the dynamics of track/trains; wheel/rail interaction related to acceleration and braking; horizontal and vertical geometric design of railroads and rail-bed design, rail structures; freight and passenger operations; and, rail-highway interaction and safety.
**Prerequisites:** CIV-ENGR 481.

CIV-ENGR 5599 Thesis Research Credits: 1-6
Independent investigation in the field of civil engineering to be presented in the form of a thesis.

CIV-ENGR 5601AE Advanced Topics In Civil Engineering Credits: 1-3
CIV-ENGR 5601AS Doctoral Topics Civil Engineering Credits: 1-3
CIV-ENGR 5601B Advanced Topics In Civil Engineering Credits: 1-3
CIV-ENGR 5601CH Advanced Topics In Civil Engineering Credits: 1-3
CIV-ENGR 5601FM Doctoral Topics in Civil Engineering Credits: 1-3
Current technical developments in civil engineering.
CIV-ENGR 5601G Advanced Topics In Civil Engineering Credits: 1-3
CIV-ENGR 5601RE Advanced Topics In Civil Engineering Credits: 1-3
Advanced Topics In Civil Engineering
CIV-ENGR 5601SD Advanced Topics In Civil Engineering Credits: 1-3
CIV-ENGR 5601X Advanced Topics In Civil Engineering Credits: 1-3
CIV-ENGR 5602 Directed Reading in Civil Engineering Credits: 1-3
Faculty supervised readings course.
**Prerequisites:** Graduate standing.

CIV-ENGR 5607 Numerical Methods in Engineering Credits: 3
Classification and numerical solution of engineering problems--ordinary and partial differential equations, algebraic equations. Includes initial, boundary, eigen-# and characteristic-value problems.
**Prerequisites:** MATH 345.

CIV-ENGR 5622 Theory of Elasticity Credits: 3
**Cross Listings:** MEC-ENGR 5622.

CIV-ENGR 5623 Theory of Plates and Shells Credits: 3
Bending of plates with various loading and boundary conditions. Deformations, stresses in thin shells.
**Prerequisites:** CIV-ENGR 5622.
**Cross Listings:** MEC-ENGR 5623.

CIV-ENGR 5624 Theory of Elastic Stability Credits: 3
Buckling of columns, beams, rings, curved bars, thin plates, shells.
**Prerequisites:** CIV-ENGR 5622.
**Cross Listings:** MEC-ENGR 5624.

CIV-ENGR 5625 Advanced Prestressed Concrete Credits: 3
Design and behavior of prestressed concrete structures; material and system of pretensioned and post tensioned systems; prestress losses; flexure, shear, bond, deflections and partial prestress in determinate structures; indeterminate beams-introduction.
**Prerequisites:** CIV-ENGR 422WI.
CIV-ENGR 5629 Adv. Design of Structures for Blast and Fire Credits: 3
General overview of Blast Design; risk assessment and design criteria; simplified Blast Effects Analysis; ground shock, material response; antiterrorism design considerations; weapons effects and mitigation; internal explosions; progressive collapse analysis; and introduction to Fire Design.

CIV-ENGR 5645 Water Quality Modeling Credits: 3
Derivation and application of models for describing oxygen budget, nutrient exchange, and biological productivity in streams, lakes and estuaries. **Prerequisites:** CIV-ENGR 342.

CIV-ENGR 5646 Physiochemical Treatment Processes Credits: 3
Fundamental principles, analysis and modeling of physical and chemical processes for water and wastewater treatment. **Prerequisites:** CIV-ENGR 342.

CIV-ENGR 5647 Biochemical Treatment Processes Credits: 3
Biochemical principles, kinetic models and energy considerations in the design of biological wastewater treatment processes. **Prerequisites:** CIV-ENGR 342.

CIV-ENGR 5648 Environmental Engineering Practicum Credits: 3
Numerical water quality modeling of actual site data for wasteload allocation. **Prerequisites:** CIV-ENGR 5645.

CIV-ENGR 5649 Design of Water and Wastewater Treatment Facilities Credits: 3
Development of design criteria and their application to the design of water and wastewater treatment facilities. **Prerequisites:** CIV-ENGR 5646 or CIV-ENGR 5647.

CIV-ENGR 5651 Fundamentals of Fluid Mechanics Credits: 3
Fundamentals of fluid motion, lecture and laboratory. Instrumentation, technique and analysis for experimental studies in fluid mechanics.

CIV-ENGR 5655 Sediment Transport Credits: 3
The study of sediment transport in rivers: the relationship between sediment transport and the fundamentals of fluvial geomorphology. Computation of sediment transport and sediment transport modeling. **Prerequisites:** CIV-ENGR 452 (or CIV-ENGR 5552).

CIV-ENGR 5656 Advanced Hydraulic Engineering Credits: 3
Rapidly varied flow and design of transition structures. Hydraulic design of spillways, reservoirs and related structures.

CIV-ENGR 5657 Advanced Seismic Design of Structures Credits: 3
Introduction to basic analysis and design principles for the seismic design of buildings (concrete, steel, wood). General seismic principles, codes and loads, static lateral force procedure, dynamic lateral force procedure, topics in rigidities of buildings. **Prerequisites:** CIV-ENGR 323 (or CIV-ENGR 422WI), MEC-ENGR 285.

CIV-ENGR 5659 Dynamics of Structures Credits: 3
Study of the dynamic behavior of structures. Analysis of equivalent lumped parameter systems for the design of structures in a dynamic environment. **Prerequisites:** CIV-ENGR 276 (or CIV-ENGR 421), MEC-ENGR 484 (or MATH 345, MEC-ENGR 285). **Cross Listings:** MEC-ENGR 5679.

CIV-ENGR 5681 Traffic Flow Theory Credits: 3
This course covers the review of macroscopic and microscopic traffic flow characteristics, the traffic flow models, and the traffic simulation applications. **Prerequisites:** CIV-ENGR 319, CIV-ENGR 481.

CIV-ENGR 5682 Transportation Network Modeling Credits: 3
This course is about modeling, solving, and understanding network flow problems, especially in the transportation discipline. This course covers equilibrium traffic assignment, network design, fleet assignment, fleet routing, and crew scheduling. **Prerequisites:** CIV-ENGR 319, CIV-ENGR 481.

CIV-ENGR 5699 Research and Dissertation Credits: 1-9
Doctoral dissertation research.
Computer Science Courses

COMP-SCI 100 Computer Fundamentals and Applications Credits: 3
The course covers essential computer concepts and skills. The emphasis is on using the computer as a tool to enhance productivity. Topics include basic computer concepts such as what to look for when buying a computer and how to avoid hackers and viruses when operating one. Students will also learn how to create word processing, spreadsheet, database, and presentation documents using the Microsoft Office suite of applications. The course prepares students to succeed in both college and business by enabling them to write reports, analyze and chart data, prepare presentations and organize large data sets.
Prerequisites: MATH 110.

COMP-SCI 101 Problem Solving and Programming I Credits: 3
Problem solving, algorithms, and program design. Use of structured programming, lists, control structures, recursion, objects and files in Python. Introduction to graphical interface programming. Coding, testing and debugging using a modern development environment.
Prerequisites: MATH 110 or higher, ALEKS score of 51 or higher.
Co-requisites: COMP-SCI 101L.

COMP-SCI 111 Introduction to Computing Credits: 3
This course provides a broad and general introduction to the computing fields underlying computer science, information technology and computer engineering and its impact on humanity and society. It introduces important concepts of the field, including hardware, software, communications networks, algorithmic processes, information representation, and programming. The course is not programming oriented, but some light programming might be required. The course also introduces academic skills and strategies for success as a student and in a professional career.

COMP-SCI 190 Special Topics Credits: 1-3
Selected introductory topics in the area of computing. May be repeated for credit when topic varies.

COMP-SCI 190A Special Topics Credits: 1-3
Selected introductory topics in the area of computing. May be repeated for credit when topic varies.

COMP-SCI 191 Discrete Structures I Credits: 3
Mathematical logic, sets, relations, functions, mathematical induction, algebraic structures with emphasis on computing applications.
Prerequisites: MATH 110 or higher, ALEKS score of 51 or higher.

COMP-SCI 201L Problem Solving and Programming II - Lab Credit: 1
Programming exercises and demonstrations to reinforce concepts learned in COMP-SCI 201R and provide additional practice in C++ programming.
Prerequisites: COMP-SCI 101, COMP-SCI 191.
Co-requisites: COMP-SCI 201R.

COMP-SCI 201R Problem Solving and Programming II Credits: 3
Problem solving and programming using classes and objects. Algorithm efficiency, abstract data types, searching and sorting, templates, pointers, linked lists, stacks and queues implemented in C++.
Prerequisites: COMP-SCI 101, COMP-SCI 191.
Co-requisites: COMP-SCI 201L.

COMP-SCI 281R Introduction to Computer Architecture and Organization Credits: 3
Digital Logic and Data Representation, process architecture and instruction sequencing, memory hierarchy and bus-interfaces and functional organization.
Prerequisites: COMP-SCI 101, COMP-SCI 191.

COMP-SCI 282 Assembly Language Programming Credits: 3
Use of an assembly language for a virtual machine, internal representation of data and instructions, the assembly process, linking, loading and program relocation and execution. I/O, exception handling, alternative architectures.
Prerequisites: COMP-SCI 201R, COMP-SCI 281R.

COMP-SCI 290 Special Topics Credits: 1-3
Selected intermediate topics in the area of computing. May be repeated for credit when topic varies.

COMP-SCI 291 Discrete Structures II Credits: 3
Prerequisites: COMP-SCI 191.
COMP-SCI 303 Data Structures Credits: 3
Linear and hierarchical data structures, including stacks, queues, lists, trees, priority queues, advanced tree structures, hashing tables, dictionaries and disjoint-set. Abstractions and strategies for efficient implementations will be discussed. Linear and hierarchical algorithms will be studied as well as recursion and various searching and sorting algorithms. Programming concepts include Object Orientation, concurrency and parallel programming. Several in-depth projects in C++ will be required.
Prerequisites: COMP-SCI 191, COMP-SCI 201R, and COMP-SCI 201L.

COMP-SCI 304WI Ethics and Professionalism Credits: 3
Societal and ethical obligations of computer science, information technology, and electrical/computer engineering practice. Topics include obligations of professional practice, electronic privacy, intellectual property, ethical issues in networking, computer security, computer reliability, and whistle-blowing.
Prerequisites: ENGLISH 225, RooWriter.

COMP-SCI 349 Java Programming with Applications Credits: 3
The course covers the syntax and semantics of the Java programming language along with the use of essential class libraries. These topics will be taught in the context of application development. Students will learn how to write small to medium sized Java applications and applets. Specific topics covered include: essential classes in the Java API, interfaces, inheritance, exceptions, graphical user interface components, layout managers, events, I/O classes, Applets, data base access, and multithreading. Other topics will be covered as time permits.
Prerequisites: COMP-SCI 303.

COMP-SCI 352 Data Structures and Algorithms Credits: 3
Abstract data structures and analysis of associated algorithms, abstractions as separate from implementation. Structures include lists, trees, priority queues, advanced tree structures, hashing tables, and graphs. Comparison of efficiency of algorithms as implemented with various data structures. Advanced searching and sorting algorithms, shortest paths, spanning tree and flow algorithms. Introduction to the basic concepts of NP-complete problems.
Prerequisites: COMP-SCI 201R (or E&C-ENGR 216 for EC-ENGR students), COMP-SCI 291, MATH 210.

COMP-SCI 371 Database Design, Implementation and Validation Credits: 3
This course discusses in detail all aspects of ORACLE database management systems. It covers in detail database design, implementation, and validation using ORACLE. In addition to these, it briefly covers ORACLE implementation, tuning, and implementation. The course is suitable for undergraduates and professionals alike.
Prerequisites: COMP-SCI 303 (or COMP-SCI 352).

COMP-SCI 390 Special Topics Credits: 1-3
Selected topics in the area of computing at the junior level. May be repeated for credit when the topic varies.

COMP-SCI 393 Numerical Analysis and Symbolic Computation Credits: 3
Basic elements of numerical analysis: numerical solution of algebraic equations, solution of linear simultaneous algebraic equations, matrices, eigenvalues and eigenvectors, numerical integration and numerical solution of linear differential equations. Use of a symbolic manipulator on both symbolic and numerical computation, applied to the above listed basic elements of numerical analysis.
Prerequisites: COMP-SCI 201R, COMP-SCI 281R, MATH 250.

COMP-SCI 394R Applied Probability Credits: 3
Basic concepts of probability theory. Counting and measuring. Probability, conditional probability and independence. Discrete, continuous, joint random variables. Functions of random variables. Sums of independent random variables and transform methods. Random number generation and random event generation. Law of large numbers, central limit theorem, inequalities. Their applications to computer science and electrical and computer engineering areas are stressed.
Prerequisites: COMP-SCI 201R and COMP-SCI 201L (or E&C-ENGR 216), MATH 220, and STAT 235 (or E&C-ENGR 241).

COMP-SCI 396 Fundamentals of Communication and Network Security Credits: 3
Techniques learned in this course provide security solutions for a variety of security threats across the spectrum of communications and network applications. This course covers both fundamental cryptology and applications, including conventional encryption, modular arithmetic, data encryption standard, public-key cryptography, RSA, wireless communication security, secure email, Internet payment and secure web applications.
Prerequisites: MATH 300.

COMP-SCI 404 Introduction to Algorithms and Complexity Credits: 3
A rigorous review of asymptotic analysis techniques and algorithms: from design strategy (such as greedy, divide-and-conquer, and dynamic programming) to problem areas (such as searching, sorting, shortest path, spanning trees, transitive closures, and other graph algorithms, string algorithms) arriving at classical algorithms with supporting data structures for efficient implementation. Throughout, the asymptotic complexity is studied in worst case, best case, and average case for time and/or space, using appropriate analysis techniques (recurrence relations, amortization). Introduction to the basic concepts of computability and NP-complete theory.
Prerequisites: COMP-SCI 291, COMP-SCI 303 (or COMP-SCI 352).

COMP-SCI 411 Introduction to Telecommunications Systems Credits: 3
Representation of signals and systems, Fourier Series, Fourier Transform, transmission of signal through linear system, amplitude modulation systems, frequency and pulse modulation systems, sampling, time division multiplexing, digital modulation and noise in modulation systems.
Prerequisites: COMP-SCI 394R, MATH 250.

COMP-SCI 420 Introductory Networking and Applications Credits: 3
This introductory course examines the systems aspects of the different LAN/MAN/WAN models, including topics such as protocols, network operating systems, applications, management and wireless communication systems. It also examines how the different models are interconnected using bridges and routers.
Prerequisites: Senior standing.

COMP-SCI 421A Foundations of Data Networks Credits: 3
This introductory course examines the analytical aspects of data communications and computer networking. Topics cover protocol concepts and performance analysis that arise in physical, data link layer, MAC sub layer, and network layer.
Prerequisites: COMP-SCI 291, COMP-SCI 303, COMP-SCI 394R.

COMP-SCI 423 Client/Server Programming and Applications Credits: 3
Fundamentals of Client/Server programming using socket interface; features of network programming including connection oriented and connectionless communication in multiple environments (Windows, UNIX, and Java); other client/server mechanisms, such as RPC and RMI) and formal object environments designed to facilitate network programming (CORBA, COM and Beans).
Prerequisites: COMP-SCI 352 (or COMP-SCI 303, COMP-SCI 431).

COMP-SCI 424 Software Methods and Tools Credits: 3
This course covers a number of software methods and tools that are widely used in industry. These methods include architecture patterns and styles, software frameworks, unit testing, and version control. The covered software tools include Microsoft Project, IBM Rational Systems Modeler, Eclipse Plug-ins, JUnit, Subversion, and GIT. The course emphasizes practice. Students will use these methods and tools to develop a software system from the initial planning to final deployment.
Prerequisites: COMP-SCI 349.

COMP-SCI 431 Introduction to Operating Systems Credits: 3
This course covers concurrency and control of asynchronous processes, deadlocks, memory management, processor and disk scheduling, x86 assembly language, parallel processing, and file system organization in operating systems.
Prerequisites: COMP-SCI 303, COMP-SCI 281R.

COMP-SCI 441 Programming Languages: Design and Implementation Credits: 3
This course covers programming language paradigms (object-oriented programming, functional programming, declarative programming, and scripting) and design tradeoffs in terms of binding, visibility, scope, lifetime, type-checking and abstraction. It also covers programming language specification, grammar, lexical analysis, exception handling, and runtime considerations.
Prerequisites: COMP-SCI 303.

COMP-SCI 444 Compiler/Translator Design Credits: 3
This course will teach modern compiler techniques applied to both general-purpose and domain-specific languages. The examples chosen will also convey a detailed knowledge of state-of-the art based WWW technology. The fundamental goal of programming is to provide instructions to the computer hardware. The primary purpose of the compiler/translator is to facilitate communication from the programmer via some high level language to ultimately the computer hardware. Understanding how compiler/interpreters are built and operate is important to understanding efficiency of operation and storage.
Prerequisites: COMP-SCI 303 (or COMP-SCI 352).

COMP-SCI 449 Foundations of Software Engineering Credits: 3
The course introduces concepts of Software Engineering (definitions, context) and the Software Development Process (life cycle). Students will get a solid foundation in Agile methodology, SW requirements, Exceptions and Assertions, Verification and Validation, SW Models and modeling, and User Interface Design. Various SW Architectures will be discussed.
Prerequisites: COMP-SCI 303 (or COMP-SCI 352).

COMP-SCI 451R Software Engineering Capstone Credits: 3
The course will focus on the requirements and project planning and managing of medium sized projects with deliverables of each phase of the software life cycle. Additional studies of software modeling, requirements specifications, configuration management, verification, validation, software evolution and quality and finally measurement, estimation and economics of the software process.
Prerequisites: COMP-SCI 303 (or COMP-SCI 352), COMP-SCI 449.
COMP-SCI 456 Human Computer Interface Credits: 3
Design of human-computer interfaces considering the psychological and physical abilities of the user. User interface design from a functional and ergonomic perspective. Contents organization, visual organization, navigation. Use of graphical interface (GUI) and the development of high quality user interfaces.
Prerequisites: COMP-SCI 449.

COMP-SCI 457 Software Architecture: Requirements & Design Credits: 3
Introduction to requirements and design engineering with emphasis on organization and presentation of system requirements and designs for customers, users and engineers; validation of requirements and design with needs of system customer; examination of requirement and design changes during the lifetime of a system; transformation of informal ideas into formal detailed descriptions; examination of the different stages in the design process including architectural design, interface design and data structure design, database design, program and transaction design; examination of domain modeling criteria and examination of design quality attributes; non-functional attributes and project resource allocation.
Prerequisites: COMP-SCI 403 (or COMP-SCI 352).

COMP-SCI 458 Software Architecture: Testing & Maintenance Credits: 3
Introduction of software system testing (including verification), software process, software reuse, software maintenance, and software re-engineering.
Prerequisites: COMP-SCI 303 (or COMP-SCI 352).

COMP-SCI 461 Introduction to Artificial Intelligence Credits: 3
This course provides an overview of the field of artificial intelligence. Topics include guided and unguided search, adversarial search, generation and use of heuristics, logic programming, probabilistic reasoning, and neural networks. Application areas studied include game playing, automated proofs, expert systems, and data mining. Recommended preparation: One or more of COMP-SCI 394R, COMP-SCI 404, or an advanced programming elective.
Prerequisites: COMP-SCI 303.

COMP-SCI 464 Applied Artificial Intelligence Credits: 3
Prerequisites: COMP-SCI 461.

COMP-SCI 465R Introduction to Statistical Learning Credits: 3
This course provides a practical introduction to analytical techniques used in data science and prepares students for advanced courses in machine learning. Topics covered include multivariate distributions, information theory, linear algebra (eigenanalysis), supervised/unsupervised learning, classification/regression, linear/non-linear learning, introduction to Bayesian learning (Bayes rule, prior, posterior, likelihood), parametric/non-parametric estimation.
Prerequisites: COMP-SCI 394R.

COMP-SCI 466R Introduction to Bioinformatics Credits: 3
This course introduces students to the field of Bioinformatics with a focus on understanding the motivation and computer science behind existing Bioinformatic resources, as well as learning the skills to design and implement new ideas.
Prerequisites: COMP-SCI 303.

COMP-SCI 470 Introduction to Database Management Systems Credits: 3
This course covers database architecture, data independence, schema, Entity-Relationship (ER) and relational database modeling, relational algebra and calculus, SQL, file organization, relational database design, physical database organization, query processing and optimization, transaction structure and execution, concurrency control mechanisms, database recovery, and database security.
Prerequisites: COMP-SCI 303.
Co-requisites: COMP-SCI 431.

COMP-SCI 475 Introduction to Computer Graphics Credits: 3
Interactive Computer Graphics, Hardware Interaction, 3D transformations, Shading, Lighting and Texturing.
Prerequisites: COMP-SCI 303.

COMP-SCI 490 Special Topics Credits: 1-3
Selected topics in specific areas of computer science. May be repeated for credit when the topic varies.
COMP-SCI 490CI Special Topics Credits: 1-3
COMP-SCI 490CR Special Topics Credits: 1-3
COMP-SCI 490IS Special Topics Credits: 1-3
COMP-SCI 490JU Special Topics Credits: 1-3
COMP-SCI 490MT Special Topics Credits: 1-3
COMP-SCI 490NN Special Topics Credits: 1-3
COMP-SCI 490SA Special Topics Credits: 1-3
Special Topics
COMP-SCI 490SI Special Topics Credits: 1-3
COMP-SCI 490SM Special Topics Credits: 1-3
COMP-SCI 491 Internship Credits: 6
Students may participate in structured internships under the joint supervision of an employer and a faculty member. The student must carry out significant professional responsibilities that also have academic merit. The number of credit hours is based on the quality of the academic experience. Available for credit/no credit only and students must be in good standing with at least 18 credit hours of CS/IT counting towards the degree. Registration by consent number only: petition forms for CS/IT491 Internships are available in the office of CSEE Division and on the web.
Prerequisites: Junior standing.

COMP-SCI 494R Applied Stochastic Models Credits: 3
Review of basic probability including properties of joint random variables and functions of random variables. Discrete and continuous random processes, such as the Poisson process, Brownian motion, and white Gaussian noise. Linear filtering of random processes. Markovian birth and death processes and elementary queuing theory.
Prerequisites: COMP-SCI 394R.

COMP-SCI 497 Directed Readings Credits: 1-3
Readings in an area selected by an undergraduate student in consultation with a faculty member. Arrangements must be made prior to registration.

COMP-SCI 498 Research Seminar Credits: 1-3
Undergraduate research based on intensive readings from the current research literature under the direction of a faculty member. Arrangements must be made prior to registration.

COMP-SCI 499 Undergraduate Research Credits: 1-3
Completion of project, including a final written report, under the direction of a faculty member. A prospectus must be accepted prior to registration.

COMP-SCI 5101 Discrete Structures Review for Graduate Students Credits: 1-3
A review of mathematical logic, sets, relations, functions, mathematical induction, and algebraic structures with emphasis on computing applications. Recurrence relations and their use in the analysis of algorithms. Graphs, trees, and network flow models. Introduction to Finite state machines, grammars, and automata. Students must have completed College Algebra before taking this course.

COMP-SCI 5102 Operating Systems Review for Graduate Students Credits: 1-3
This course covers concurrency and control of asynchronous processes, deadlocks, memory management, processor and disk scheduling, parallel processing, and file system organization in operating systems.
Prerequisites: Data Structures, Computer Architecture.

COMP-SCI 5103 Advanced Data Structures and Analysis of Algorithms Review for Graduate Students Credits: 1-3
A review of linear and hierarchical data structures, including stacks, queues, lists, trees, priority queues, advanced tree structures, hashing tables, dictionaries and disjoint-sets. Asymptotic analysis techniques and algorithms: from design strategy (such as greedy, divide-and-conquer, and dynamic programming) to problem areas (such as searching, sorting, shortest path, spanning trees, transitive closures, graph algorithms, and string algorithms) arriving at classical algorithms with efficient implementation. Introduction to the basic concepts of complexity theory and NP-complete theory. Students must have taken courses in Linear Algebra, Discrete Structures, Data Structures, and Applied Probability before taking this course.

COMP-SCI 5510 Information Theory Credits: 3
Representation, transmission and transformation of information, information compression and protection, generation, storage, processing and transmission of information.
Prerequisites: BS in Computer Science, Engineering, or Mathematics.

COMP-SCI 5511 Advanced Telecommunications Networks Credits: 3
Efficient source coding and channel coding techniques, principles of switching, digital transmission over microwave, copper and optical media, T-carrier and SONET systems, traffic consideration in telecommunications networks, network synchronization, control and management, ATM concepts.
Prerequisites: COMP-SCI 394R, COMP-SCI 411.
COMP-SCI 5513 Digital Cellular Communications Credits: 3
Principles of microwave communications, performance metrics, mobile communications and cellular topology, co-channel and adjacent channel
interference, fading and shadowing, various types of diversity, TDMA, FDMA and CDMA and other techniques for channel assignment, cellular network
architectures, design considerations, PCN concepts.
**Prerequisites:** COMP-SCI 411.

COMP-SCI 5514 Optical Fiber Communications Credits: 3
Fiber optic cable and its characteristics, optical sources and transmitters, optical detectors and receivers, optical components such as couplers
and connectors, WDM and OFDM techniques, modulation and transmission of information over optical fibers, design of optical networks, single and
multihop fiber LANs, optical carrier systems.
**Prerequisites:** COMP-SCI 411.

COMP-SCI 5514A Optical Networking Credits: 3
Components of optical networks such as OADM, OXC, optical switches, DWDM, and their functions and interactions. Design, analysis and routing over
all-optical networks to include waveband, wavelength and lightpath routing.
**Prerequisites:** COMP-SCI 411.

COMP-SCI 5517 Digital Switching: Techniques and Architectures Credits: 3
Integration of transmission and switching, single and multistage switching principles, space and time division switching, conventional switch
architectures such as 4ESS, integration of circuit and packet switching, ATM switching and design considerations, ATM switch architectures,
evaluation and comparison, future trends.
**Prerequisites:** COMP-SCI 394R, COMP-SCI 411.

COMP-SCI 5520 Network Architecture I Credits: 3
Principles, protocols, and architectures of data networks, internetworking, routing, layering, and addressing, with specific investigation of the Internet
Protocol (IP), Mobile IP, Multiprotocol Label Switching (MPLS), IP over Asynchronous Transfer Mode (ATM) networks, and virtual private networks.
**Prerequisites:** COMP-SCI 420 (or COMP-SCI 421A), COMP-SCI 431.

COMP-SCI 5521 Network Architecture II Credits: 3
Principles, protocols and architectural issues of computer networks for transport layer and above, with specific emphasis on TCP/IP for best-effort
services as well as for emerging multi-media services.
**Prerequisites:** COMP-SCI 5520.

COMP-SCI 5522 Computer Network Design and Analysis Credits: 3
Topological design, capacity and flow assignment problem-modeling and algorithms, and their analysis, issues in network control.
**Prerequisites:** COMP-SCI 303, COMP-SCI 394R, COMP-SCI 421A.

COMP-SCI 5523 Capacity Planning for Service-Oriented Architectures Credits: 3
Web site, cloud service, and data center administrators are faced with the task of adequately sizing their Information Technology (IT) infrastructure so
that they can provide quality of service required by users at an affordable cost. In this class we will explore the Internet's complex relationships and
how these relationships impact performance and availability of Web and cloud services. The fundamentals of service oriented architectures will be
presented and we will develop performance models based on probability fundamentals and the theory of queuing networks and apply these models
toward the design and analysis of large scale information systems.
**Prerequisites:** COMP-SCI 394R, COMP-SCI 421A.

COMP-SCI 5524 Protocol Design Credits: 3
Protocols as formal algorithms, architectural definition, protocol specification languages and models and their translation to implementation
languages, overview of verification methods, symbolic execution.
**Prerequisites:** COMP-SCI 421A.

COMP-SCI 5525 Cloud Computing Credits: 3
Cloud computing systems operate on a very large scale, and are impacting the economics and the assumptions behind computing significantly.
This special topics course provides a comprehensive overview of the key technical concepts and issues behind cloud computing systems such as
compute, storage and network resource virtualization and management. We will cover a range of topics of cloud computing including: Cloud system
architectures and taxonomy, Computing virtualization techniques, Virtual machine resource management, Data center networking issues, Big data
transfer protocols and management, Large scale distributed file system examples (Google File System), Cloud programming.
**Prerequisites:** CSEE 5110, COMP-SCI 431.

COMP-SCI 5526 Network Routing Credits: 3
Algorithms, protocols and analysis for network routing. Routing in different networks such as circuit-switched networks, Internet, broadband networks,
and transmission networks are covered.
**Prerequisites:** COMP-SCI 5520, COMP-SCI 5522.
COMP-SCI 5528 Local Area Networks: Analysis and Design Credits: 3
Definition of local area networks (LAN), LAN architecture and protocols, topology, transmission media, channel access protocols, modeling, simulation and performance evaluation of LANs, considerations in design and implementation, examples.
Prerequisites: COMP-SCI 421A, COMP-SCI 494R.

COMP-SCI 5531 Advanced Operating Systems Credits: 3
Components of an operating system, scheduling/routing mechanisms, process control blocks, design and test various operating system components.
Prerequisites: COMP-SCI 431.

COMP-SCI 5532 Discrete Event Simulation Credits: 3
Review of statistical distributions, generation of pseudorandom variates and stochastic processes, basic queueing systems such as M/M/m and Jackson Networks, simulation project.
Prerequisites: COMP-SCI 5594.

COMP-SCI 5540 Principles of Big Data Management Credits: 3
This course will introduce the essential characteristics of Big Data and why it demands rethinking how we store, process, and manage massive amounts of structured and unstructured data. It will cover the core technical challenges in Big Data management i.e., the storage, retrieval, and analysis of Big Data. It will emphasize on fundamental concepts, analytical skills, critical thinking, and software skills necessary for solving real-world Big Data problems. Tools such as Apache Hadoop, Pig, Hive, HBase, and Apache Spark will be covered. Extensive reading of research papers and in-class presentations will be heavily emphasized in this class.
Prerequisites: COMP-SCI 431 (or equivalent) and COMP-SCI 470 (or equivalent).

COMP-SCI 5542 Big Data Analytics and Applications Credits: 3
Big Data analytics focus on analyzing large amounts of data to find useful information and to make use of the information for better business decisions. This course introduces students to the practice and potential of big data analytics and applications. In this course, students will have hands-on experience with Big Data technologies (Hadoop and its ecosystems) and tools (Cloudera, RMahout, HBase) for the analysis of large data sets across clustered systems. Students will learn how to develop highly interactive applications for business intelligence.
Prerequisites: Software Engineering (COMP-SCI 451).

COMP-SCI 5543 Real-time Big Data Analytics Credits: 3
This course teaches students fundamental theory and practice in the field of big data analytics and real time distributed systems for real time big data applications. In this course, students will have hands-on experience for the development of real-time applications with various tools such as Twitter’s Storm, Apache Flume, Apache Kafka for real time analysis of stream data such as twitter messages and Instagram images.
Prerequisites: Software Engineering (COMP-SCI 451).

COMP-SCI 5551 Advanced Software Engineering Credits: 3
Current concepts in software architecture and design, comparative analysis for design, object-oriented software design, software quality criteria for evaluation of software design. Introduction to metrics, project management and managerial ethics.
Prerequisites: COMP-SCI 451R.

COMP-SCI 5552 Advanced Data Structures Credits: 3
Formal modeling including specification and deviation of abstract data types, completeness issues in the design of data types and data structures, implementation of data structures from a formal data type specification, verification of abstract to concrete data mapping.
Prerequisites: COMP-SCI 291, COMP-SCI 303.

COMP-SCI 5552A Formal Software Specification Credits: 3
Formal modeling including specification and deviation of abstract data types, completeness issues in the design of data types and data structures, implementation of data structures from a formal data type specification, verification of abstract to concrete data mapping.
Prerequisites: COMP-SCI 291, COMP-SCI 303.

COMP-SCI 5553 Software Architecture and Design Credits: 3
The course introduces a number of basic concepts and enabling technologies of software architecture, including architecture styles, architecture description languages, architecture-implementation mapping, and product line architectures. It also covers some advanced topics, such as the REST architecture style and Web Services. Students will read research papers, analyze the existing results, write critiques, give presentations, and exercise the research results with real examples. In addition, students will have an opportunity to work in groups and study the architecture of some real software systems.
Prerequisites: COMP-SCI 451R or equivalent.

COMP-SCI 5554 Software Tools and Programming Environments Credits: 3
Taxonomy of software tools and environments, generic software tool architecture, interface techniques for users, intra-system and stand-alone systems, integration of heterogeneous systems components.
Prerequisites: COMP-SCI 451R.
COMP-SCI 5555 Software Methods and Tools Credits: 3
Software methods and tools are extensively used in current software production to improve software productivity and quality. In this course, we are going to learn a number of popular software methods and tools being used in industry. These methods include object-oriented design and analysis (e.g. UML, design patterns), architecture styles, code generation, and unit testing. The covered software tools include Microsoft Project, IBM Rational Systems Developer, Eclipse Plug-ins, Emacs, JUnit, Subversion, and GIT. The course emphasizes practice, and students will be using these methods and tools to develop a software system, from the initial planning to the final deployment.
Prerequisites: COMP-SCI 349.

COMP-SCI 5556 Human Factors in Computer Systems Credits: 3
Design of "user friendly" man-machine interface, survey of recent psychological studies in man-machine interaction, user interface design, instrumentation and testing, analytic models of man-machine interaction.
Prerequisites: COMP-SCI 451R.

COMP-SCI 5560 Knowledge Discovery and Management Credits: 3
This course teaches students fundamental theory and practice in the field of knowledge discovery and management and also provides them with hands-on experience through application development.
Prerequisites: COMP-SCI 5551, COMP-SCI 461 (or COMP-SCI 464).

COMP-SCI 5561 Advanced Artificial Intelligence Credits: 3
AI systems and their languages, implementations and applications, case studies of various expert systems, current research topics in AI, logic programming using PROLOG.
Prerequisites: COMP-SCI 461.

COMP-SCI 5564 Inference Techniques and Knowledge Representation Credits: 3
Inference Techniques is an in-depth course of logic and automatic theorem proving, intended for Computer Science graduate students, with particular importance to those students interested in Artificial Intelligence. The main areas of study will be concerned with the principals and techniques used for automatic theorem proving. An overview of the representation of knowledge and logic, a detailed appreciation of theorem proving methods, and implementation techniques will be provided in the course. The course will provide background for further study in varying fields of A.I.
Prerequisites: COMP-SCI 461.

COMP-SCI 5565 Introduction to Statistical Learning Credits: 3
Introduction to Machine Learning; Multivariate Distributions; Information Theory; Linear Algebra (Eigenanalysis); Supervised/Unsupervised Learning; Classification/Regression; Linear/Non-linear Learning; Introduction to Bayesian Learning (Bayes rule, Prior, Posterior, Maximum Likelihood); Parametric/Non-parametric Estimation.
Prerequisites: Required - Applied Probability (COMP-SCI 394R). Recommended - Linear Algebra (MATH 300); Familiarity with MATLAB or R. OR Consent of instructor.

Cross Listings: COMP-SCI 465R.

COMP-SCI 5566 Introduction to Bioinformatics Credits: 3
This course introduces students to the field of Bioinformatics with a focus on understanding the motivation and computer science behind existing Bioinformatic resources, as well as learning the skills to design and implement new ideas.
Prerequisites: COMP-SCI 303, a course or background in Biology (Genomics or Meta Models preferred).

COMP-SCI 5567 Machine Learning for Data Scientists Credits: 3
This course teaches the theoretical basis of methods for learning from data, illustrated by examples of applications to several domains. Recommended preparation: COMP-SCI 5565.
Prerequisites: COMP-SCI 303, COMP-SCI 394R, COMP-SCI 330.

COMP-SCI 5568 Fundamentals of Probabilistic Graphical Models Credits: 3
Many real world systems are probabilistic in nature. Probability theory gives us the basic tools for modeling many real world systems, allowing us to understand complex behavior. Probabilistic graphical models allow us to model complex probabilistic relationships using graphs. This framework, which spans methods such as Bayesian networks and Markov networks, allows us to manipulate complex probability distributions that often involve hundreds or even many thousands of variables. These methods have been used for an enormous range of applications, which include: web search, turbo coding, robot navigation, image identification, epidemic identification in complex networks, medical diagnosis and speech recognition.
Prerequisites: COMP-SCI 303, COMP-SCI 394R, COMP-SCI 330, Recommended COMP-SCI 5565.

COMP-SCI 5570 Architecture of Database Management Systems Credits: 3
Covers in detail, architecture of centralized database systems, database processing, management of concurrent transactions, query processing, query optimization, data models, database recovery, data warehousing, workflow, World Wide Web and Database performance, and reviews the architecture of some commercial centralized database systems.
Prerequisites: COMP-SCI 431, COMP-SCI 470.
COMP-SCI 5571 Distributed Database Management Systems Credits: 3
Detailed study of distributed database systems architecture, in-depth study of distributed transaction management, distributed concurrency control and recovery algorithms, database distribution, distributed query optimization and analysis of database system design, and intelligent network databases.
Prerequisites: COMP-SCI 5570.

COMP-SCI 5572 Mobile Computing Credits: 3
This course covers in detail the architecture of mobile and wireless network. It discusses and develops reveland concepts and algorithms for building mobile database systems (MDS), which is necessary for managing information on the air and E-commerce.
Prerequisites: COMP-SCI 5570.

COMP-SCI 5573 Information Security and Assurance Credits: 3
This course deals with information security and assurance and covers the concepts necessary to secure the cyberspace. It introduces security models, assurance policies, security policies and procedures, and technology. It enables students to understand the need for information assurance, identify security vulnerabilities, and devise security solutions that meaningfully raise the level of confidence in computer systems. It teaches students how to design secured database and computer systems.
Prerequisites: COMP-SCI 5570.

COMP-SCI 5574 Large Scale Semistructured Data Management Credits: 3
This course will cover topics related to managing large scale semistructured data modeled using the Extensible Markup Language XML and the Resource Description Framework (RDF). This will include storing XML (e.g. natively, using a relational database), indexing XML (e.g. numbering schemes, structural indexes, sequencing paradigms), XML query processing algorithms (e.g. join-based, subsequence-based), RDF DATA STORAGE (e.g. triple stores, graph stores), RDF indexing and SPARQL query processing algorithms. The course will also cover emerging many core processor architectures (e.g. Intel Single-chip Cloud Computer) and the opportunities they provide for building next-generation semistructured data management solutions. Extensive reading of research papers and in-class presentations will be a core part of this class. Grades will be based on in-class presentations of research papers, exams, and a research project (to be done in groups).
Prerequisites: COMP-SCI 470 (or equivalent).

COMP-SCI 5575 Advanced Computer Graphics Credits: 3
Review of transformations, 3D viewing, curve fitting in 3D, generation of surfaces, hidden surface elimination, scan-line coherence, rigid solid representation, shading, color theory.
Prerequisites: COMP-SCI 475.

COMP-SCI 5581 Parallel Computer Architecture I Credits: 3
Parallelism in computer architecture, pipelined processors, array processors and multi-processor systems, algorithms for SISD, SIMD, MISD and MIMD organizations, vectorization, pipelining algorithms.

COMP-SCI 5590 Special Topics Credits: 1-3
Selected topics in specific areas of computer science. May be repeated for credit when the topic varies.

COMP-SCI 5590AW Special Topics Credits: 1-3
COMP-SCI 5590BD Special Topics Credits: 1-3
COMP-SCI 5590CC Special Topics In Computer Science Credits: 1-3
COMP-SCI 5590CI Special Topics Credits: 1-3
COMP-SCI 5590CN Special Topics Credits: 1-3
COMP-SCI 5590HI Special Topics Credits: 1-3
COMP-SCI 5590MT Special Topics Credits: 1-3
COMP-SCI 5590NN Special Topics Credits: 1-3
Selected topics in specific areas of computer science. May be repeated for credit when the topic varies.

COMP-SCI 5590OS Special Topics Credits: 1-3
COMP-SCI 5590PB Special Topics Credits: 1-3
Special Topics
COMP-SCI 5590PG Special Topics In Computer Science Credits: 1-3
COMP-SCI 5590SA Special Topics In Computer Science Credits: 1-3
COMP-SCI 5590WW Special Topics Credits: 1-3
COMP-SCI 5590WX Special Topics Credits: 1-3
COMP-SCI 5590XX Special Topics Credits: 1-3
COMP-SCI 5590YL Special Topics Credits: 1-3
COMP-SCI 5591 Concurrency Models Credits: 3
Concurrency control constructs, P/V primitives, cobegin/coend, monitors, message transmission, rendezvous systems, underlying mathematics of concurrent systems, Petri Nets, liveness (deadlock), reachability, boundedness, invariants, system modeling.
Prerequisites: COMP-SCI 431.

COMP-SCI 5592 Design and Analysis of Algorithms Credits: 3
Combinatorial analysis, searching and sorting, shortest path algorithms, spanning trees, search and traversal techniques, backtracking, branch and bound, heuristics, algebraic simplification and transformation.
Prerequisites: COMP-SCI 303 and COMP-SCI 404.

COMP-SCI 5594 Introduction to Queuing Theory Credits: 3
Review of statistics and probability, stochastic processes, Markov Processes, the basic Poisson process, equilibrium conditions, M/M/1 system with variations local and global balance in networks of queues, open and closed networks.
Prerequisites: COMP-SCI 494R.

COMP-SCI 5595 Mathematical Foundations of Computer Science Credits: 3
Study of the theory, and algorithmic techniques, of the fields of graph theory, combinatorics and number theory, as they relate to their application in the field of computer science.
Prerequisites: COMP-SCI 303, COMP-SCI 494R.

COMP-SCI 5596A Computer Security I: Cryptology Credits: 3
Study of theory, and algorithmic techniques, of the fields of number theory and cryptology, as they are applied in the general area of computer and network security.
Prerequisites: COMP-SCI 291.

COMP-SCI 5596B Computer Security II: Applications Credits: 3
Application of the algorithmic techniques learned in COMP-SCI 5596A to provide suitable security countermeasures to the variety of security threats across the spectrum of computing.
Prerequisites: COMP-SCI 5596A.

COMP-SCI 5597 Directed Readings Credits: 1-3
Readings in an area selected by the graduate student in consultation with a faculty member. Arrangements must be made prior to registration.

COMP-SCI 5598 Research Seminar Credits: 1-3
Graduate research based on intensive readings from the current research literature under the direction of a faculty member. Arrangements must be made prior to registration.

COMP-SCI 5599 Research and Thesis Credits: 1-6
A project investigation leading to a thesis, or written report under the direction of a faculty member. A prospectus must be accepted prior to registration.

COMP-SCI 5622 Advanced Network Analysis Credits: 3
Design and analysis of data networks, comparative analysis of capacity and flow strategies, time-delay/cost trade offs, concentration and buffering in store and forward networks, random access techniques, pure, slotted and reservation type Aloha schemes, carrier sense multiple access.
Prerequisites: COMP-SCI 5522.

COMP-SCI 5623 Network Simulation and Modeling Credits: 3
Simulation and modeling of network topologies and protocols, evaluation of the physical layer, data-link layer, network layer routing algorithms, local and long-haul networks.
Prerequisites: COMP-SCI 5522, COMP-SCI 5532.

COMP-SCI 5651 Distributed Computing for Software Systems Credits: 3
Formal descriptions of problems encountered in distributed computing for architecture. Parameters to formal requirements, operating system support, communications support, process synchronization, and system verification, distinctions between real time and concurrent time. The nature of life cycles, project organization and use of automated tools.
Prerequisites: COMP-SCI 5531 (or COMP-SCI 5551 or COMP-SCI 5570).
COMP-SCI 5690 Advanced Special Topics Credits: 1-3
A lecture course presenting advanced research level topics. This course is intended to allow faculty and visiting scholars to offer special courses in selected research areas.
Prerequisites: Ph.D. Candidacy.

COMP-SCI 5690ND Advanced Special Topics Credits: 1-3

COMP-SCI 5694 Advanced Queueing Theory Credits: 3
Non-Markovian systems such as M/G/1, G/M/1 and G/G/1, solutions of networks of non-Markovian nodes, queuing network approximate solution techniques.
Prerequisites: COMP-SCI 5594.

COMP-SCI 5697 Directed Readings Credits: 1-3
Readings in an area selected by the doctoral student in consultation with a doctoral faculty member. Arrangements must be made prior to registration.

COMP-SCI 5698 Advanced Research Seminar Credits: 1-3
Advanced research by a group of doctoral students based on intensive readings from the current research literature under the direction of one or more doctoral faculty. Original research results of each student are exchanged by presentations and group discussion. Arrangements must be made prior to registration.

COMP-SCI 5699A Research And Dissertation Research In Computer Science Credits: 1-12
Doctoral research in computer science.

COMP-SCI 5899 Required Grad Enrollment Credit: 1

Computer Sci Electrical Engr Courses

CSEE 5110 Network Architecture I Credits: 3
This course provides an introduction to fundamental concepts and principles in the design and implementation of computer communication networks, their protocols, and architectures. Topics to be covered include: layering, addressing, naming, routing, internetworking, Internet protocols, reliable transfer, congestion control, link control, multiple media access, and network measurement and management.
Prerequisites: COMP-SCI 421A, COMP-SCI 431.

CSEE 5111 Network Architecture II Credits: 3
In this course, advanced principles, protocols, and architectures of computer networks will be studied with specific emphasis on emerging technologies. The focus will be on the latest networking protocol designs with particular attention to the TCP/IP and application layers.
Prerequisites: CSEE 5110.

CSEE 5112 Computer Network Design and Analysis Credits: 3
This course provides an introduction to analytic and simulation modeling of computer networks and network topological design. Topics covered include the analysis of delay and loss systems, topological optimization, network dimensioning, and routing coupled with analysis techniques for network planning and design.
Prerequisites: COMP-SCI 394R, COMP-SCI 421A.

CSEE 5113 Network Routing Credits: 3
Algorithms, protocols, and analysis for network routing. Routing in different networks such as circuit-switched networks, Internet, broadband networks, and transmission networks are covered.
Prerequisites: CSEE 5110, CSEE 5112.

CSEE 5130 Queuing Theory and Applications Credits: 3
This course introduces the queuing models and theory to analyze performance of computing and engineering systems in terms of delay, blocking, and buffer utilization. Both continuous and discrete time models are covered, including variations of M/M/1, M/G/1 and GI/M1 systems using quasi birth-and-death models and matrix analytic techniques. It also covers networks that can be analyzed with product form techniques. Probabilistic reasoning and intuitive understanding is stressed.
Prerequisites: COMP-SCI 394R and MATH 300.

CSEE 5590 Special Topics Credits: 1-3
This course is intended to allow faculty and visiting scholars to offer special courses in selected topics.

CSEE 5690 Advanced Special Topics Credits: 1-3
A lecture course presenting advanced research level topics. This course is intended to allow faculty and visiting scholars to offer special courses in selected research areas.

CSEE 5697 Directed Readings Credits: 1-3
Readings in an area selected by the doctoral student in consultation with a doctoral faculty member. Arrangements must be made prior to registration.

CSEE 5699 Research and Dissertation Research in Telecommunications and Computer Networking Credits: 1-12
Doctoral Research in Telecommunications and Computer Networking.
CSEE 5899 Required Graduate Enrollment Credit: 1
Required Graduate Enrollment.

**Electrical Computer Engr Courses**

E&C-ENGR 130 Engineering Graphics Credits: 3
Introduction to Engineering Graphics with the use of the Computer Aided Design tools AutoCAD and SolidWorks. Introduction to 2D design with AutoCAD and introduction to 3D design with SolidWorks. Also an introduction to electrical circuit diagrams. No previous 2D or 3D CAD experience is necessary to take this class.

E&C-ENGR 216 Engineering Computation Credits: 4
Development, analysis and synthesis of structured computer programs for solving engineering problems in the Python, MATLAB, and C languages. Introduction to algorithms and data structures.

**Prerequisites:** MATH 110.

E&C-ENGR 217 Engineering Computation Credits: 2
Students learn to develop, analyze and synthesize structured computer programs for solving engineering problems in the Python, MATLAB, and C languages. This course also provides an introduction to algorithms and data structures. This course is available by approval of the degree program committee if transfer credit has been approved for one of the listed programming languages.

**Prerequisites:** MATH 110.

E&C-ENGR 226 Logic Design Credits: 3
Design of combinational logic circuits, logic minimization techniques, design of sequential logic circuits, state machine design techniques, digital system design.

**Co-requisites:** E&C-ENGR 227.

E&C-ENGR 227 Logic Design Laboratory Credit: 1
Laboratory for E&C-ENGR 226. Experimental topics related to the design of combinational and sequential logic systems and small digital systems.

**Co-requisites:** E&C-ENGR 226.

E&C-ENGR 228 Introduction to Computer Design Credits: 3
This course covers computer organizations and fundamental computer design techniques. It also discusses design of computer data unit, control unit, input-output, microprogramming. Memory systems (RAM memory, Cache memory, interrupts, secondary memory) and direct memory access design is also discussed. Verilog HDL design is introduced and applied to small digital systems.

**Prerequisites:** E&C-ENGR 226, E&C-ENGR 227.

**Co-requisites:** E&C-ENGR 229.

E&C-ENGR 229 Introduction to Computer Design Laboratory Credit: 1
This laboratory course covers experimental topics related to the design of digital computer systems and arithmetic circuits which students study in the E&C-ENGR 228.

**Prerequisites:** E&C-ENGR 226, E&C-ENGR 227.

E&C-ENGR 241 Applied Engineering Analysis I Credits: 3

**Prerequisites:** Math 220.

E&C-ENGR 250 Engineering Mechanics and Thermodynamics Credits: 3
This course concentrates on practical concepts in mechanics and thermodynamics for EC-ENGR majors, such as the practical use of forces, moments, couples, centroids, and moment of inertia, friction, manipulating systems of rigid bodies in motion and applying conservation of energy to gases, liquids, and solids. Materials will also be addressed.

**Prerequisites:** MATH 220, PHYSICS 240.

E&C-ENGR 276 Circuit Theory I Credits: 3
Kirchoff's circuit laws, Ohm's Law, nodal and mesh analyses, source transformations, superposition, Thevenin and Norton equivalents, transient analysis of 1st and 2nd order systems. AC circuit analysis, phasors, impedance, sinusoidal steady-state responses, operational amplifiers and PSpice.

**Prerequisites:** PHYSICS 250 and E&C-ENGR 241.

E&C-ENGR 277 Circuit Theory I Lab Credit: 1
Introduction to the use and limitations of basic instruments used in electrical testing and measurement. Experimental techniques and laboratory safety. Data gathering, interpretation and presentation. Preparation of laboratory reports. Experimental work supporting theoretical concepts developed in E&C-ENGR 276.

**Co-requisites:** E&C-ENGR 276.
E&C-ENGR 301 Fundamental Topics in Electrical and Computer Engineering Credits: 1-4
Undergraduate topics in electrical or computer engineering.

E&C-ENGR 302 Electromagnetic Waves and Fields Credits: 3
Elements of vector calculus: curl, gradient and divergence differential operations; vector identities; integration of vectors Stokes and Gauss's theorems, laplacian; review of electrostatic and magnetostatic fields; boundary value problems; boundary conditions; time-harmonic fields and phasors; Maxwell's equations, Poynting vector; vector and scalar wave equations; electromagnetic wave propagation in free-space, lossy and lossless dielectrics and conductors; polarization; reflections at normal and oblique incidences; transmission line parameters; telegraphers equations; input impedance and VSWR; Smith Chart and impedance matching; transients on transmission lines.
Prerequisites: E&C-ENGR 341R, E&C-ENGR 376, PHYSICS 250.

Co-requisites: E&C-ENGR 303.

E&C-ENGR 303 Electromagnetic Waves and Fields Lab Credit: 1
The goal of the lab is to complement and demonstrate the main concepts of transmission line and microwave theory using hands on experiments. The experiments will introduce students to microwave sources, components, and transmission lines. Moreover, the experiments will demonstrate the concepts of wave propagation, attenuation, power splitting, reflection, and standing waves. Moreover, students will design and conduct experiments to characterize unknown loads and antennas. Recommended preparation: MATLAB knowledge/proficiency.

Co-requisites: E&C-ENGR 302.

E&C-ENGR 330 Electronic Circuits Credits: 3
Application of operational amplifiers, semiconductors device physics, elementary analysis and design of analog electronic circuits that utilize diodes, BJT's, and MOSFET's in single and multistage amplifiers with passive loads and power amplifiers; DC biasing, small signal analysis and calculation of frequency responses. The use of CAD (Spice) in the analysis and design of electronic circuits.

Prerequisites: E&C-ENGR 276 and E&C-ENGR 334.

Co-requisites: E&C-ENGR 331.

E&C-ENGR 331 Electronic Circuits Laboratory Credit: 1
Laboratory experiments in the application of operational amplifiers, the analysis, design, and testing of single and multistage amplifiers with passive loads, and the measurement of frequency response.
Prerequisites: E&C-ENGR 276, E&C-ENGR 277.

Co-requisites: E&C-ENGR 330.

E&C-ENGR 334 Semiconductors and Devices Credits: 3
Junction theory, semiconductor diodes and models, bipolar transistors and models, field-effect transistors and models, selected electron devices and models.
Prerequisites: E&C-ENGR 341R, PHYSICS 250

E&C-ENGR 341R Applied Engineering Analysis II Credits: 3
Complex numbers; Euler's formulas, analytic functions, Taylor and Laurent series; Cauchy residue theorem and application to evaluation of integrals; linear algebra, eigenvalue and eigenvectors; Fourier series and transforms.
Prerequisites: E&C-ENGR 241.

E&C-ENGR 358 Introduction to Control Systems Credits: 3
Study of feedback techniques, with applications to control systems. Includes modeling, applications of Bode plot, root locus, state-variable, and Nyquist methods.
Prerequisites: E&C-ENGR 380.

E&C-ENGR 376 Circuit Theory II Credits: 3
Power, transformers, three-phase circuits, two-port networks, the theory and application of Laplace Transforms.
Prerequisites: E&C-ENGR 276.

Co-requisites: E&C-ENGR 377.

E&C-ENGR 377 Circuit Theory II Lab Credit: 1
Continuation of E&C-ENGR 277 introducing the use of additional instruments used in electrical testing and measurements. Statistical data evaluation methods. Experimental work supporting concepts developed in E&C-ENGR 376.
Prerequisites: E&C-ENGR 277.

Co-requisites: E&C-ENGR 376.
E&C-ENGR 380 Signals and Systems Credits: 3
Continuous and discrete-time signals and systems, frequency response, Fourier analysis of discrete and continuous signals and systems and use of z, Fourier, Discrete Fourier, and Fast Fourier Transforms.
Prerequisites: E&C-ENGR 341R.
Co-requisites: E&C-ENGR 381.

E&C-ENGR 381 Signals and Systems Lab Credit: 1
Computer Laboratory for E&C-ENGR 380. Various signal processing software programs (MATLAB and DSP) are used to investigate properties and applications of continuous and discrete time signals and systems.
Co-requisites: E&C-ENGR 380.

E&C-ENGR 400 Problems in Electrical and Computer Engineering Credits: 1-4
Analytic or experimental problems pertaining to electrical or computer engineering.
Prerequisites: Departmental consent.

E&C-ENGR 401 Topics In Electrical And Computer Engineering Credits: 1-4
Topics covering current and new technical developments in electrical or computer engineering.
Prerequisites: Senior standing.

E&C-ENGR 401AN Topics in Electrical Engineering Credits: 1-4

E&C-ENGR 401AR Topics in Electrical Engineering Credits: 1-4
Topics in Electrical Engineering

E&C-ENGR 401AS Topics In Electrical Engineering Credits: 1-4

E&C-ENGR 401AV Topics In Electrical Engineering Credits: 1-4

E&C-ENGR 401BE Topics in Electrical Engineering Credits: 1-4
Topics in Electrical Engineering

E&C-ENGR 401BI Topics In Electrical Engineering Credits: 1-4

E&C-ENGR 401CA Topics In Electrical Engineering Credits: 1-4

E&C-ENGR 401CI Topics in Electrical Engineering Credits: 1-4

E&C-ENGR 401DE Special Topics ECE Credits: 1-4

E&C-ENGR 401EC Topics In Electrical Engineering Credits: 1-4

E&C-ENGR 401EP Topics in ECE Credits: 1-4

E&C-ENGR 401ES Topics in Electrical Engineering Credits: 1-4
Topics in Electrical Engineering

E&C-ENGR 401FE Topics In Electrical Engineering Credits: 1-4

E&C-ENGR 401H Topics In Electrical And Computer Engineering Credits: 1-4

E&C-ENGR 401IR Topics In Electrical Engineering Credits: 1-4

E&C-ENGR 401KI Topics in Electrical and Computer Engineering Credits: 1-4
Topics covering current and new technical developments in electrical or computer engineering.
Prerequisites: Senior standing.

E&C-ENGR 401NM Topics In Electrical Engineering Credits: 1-4

E&C-ENGR 401NN Topics in Electrical and Computer Engineering Credits: 1-4
Topics covering current and new technical developments in electrical or computer engineering.
Prerequisites: Senior standing.

E&C-ENGR 401PE Topics in Electrical and Computer Engineering Credits: 1-4
Topics covering current and new technical developments in electrical or computer engineering.
Prerequisites: Senior standing.

E&C-ENGR 401PG Topics in Electrical and Computer Engineering Credits: 1-4
Topics covering current and new technical developments in electrical or computer engineering.
Prerequisites: Senior standing.

E&C-ENGR 401PL Topics in Electrical and Computer Engineering Credits: 1-4
Topics covering current and new technical developments in electrical or computer engineering.
Prerequisites: Senior standing.
E&C-ENGR 401PQ Topics in Electrical Engineering Credits: 1-4
Topics covering current and new technical developments in electrical or computer engineering.
**Prerequisites:** Senior standing.

E&C-ENGR 401PV Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 401RD Topics in Electrical and Computer Engineering Credits: 1-4
Topics covering current and new technical developments in electrical or computer engineering.
**Prerequisites:** Senior standing.

E&C-ENGR 401RS Topics in Electrical and Computer Engineering Credits: 1-4
Topics covering current and new technical developments in electrical or computer engineering.
**Prerequisites:** Senior standing.

E&C-ENGR 401SC Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 401SI Topics in Electrical Engineering Credits: 1-4
Topics in Electrical Engineering
E&C-ENGR 401VL Topics in Electrical Engineering Credits: 1-4
E&C-ENGR 401XX Topics in Electrical and Computer Engineering Credits: 1-4
Topics covering current and new technical developments in electrical or computer engineering.
**Prerequisites:** Senior standing.

E&C-ENGR 402 Senior Design I Credits: 2
First capstone design course in electrical and computer engineering. Provides and accounts for laboratory, library, research and other work needed for the development of the project. Stresses oral presentations.
**Prerequisites:** E&C-ENGR 330 and E&C-ENGR 420 or E&C-ENGR 466.

E&C-ENGR 402WI Senior Design I Credits: 2
First capstone design course in electrical and computer engineering. Provides and accounts for laboratory, library, research and other work needed for the development of the project. Stresses oral presentations.
**Prerequisites:** E&C-ENGR 330, and E&C-ENGR 420 or E&C-ENGR 466, RooWriter.

E&C-ENGR 403 Senior Design II Credit: 1
Second capstone design course in electrical and computer engineering. Project management, professional practice, ethical and engineering economic considerations and development of written and oral presentation skills. Provides laboratory experience in prototyping, fabrication, and troubleshooting of the design project. Stresses written and oral presentation.
**Prerequisites:** E&C-ENGR 402.

E&C-ENGR 403WI Senior Design II Credits: 3
Second capstone design course in electrical and computer engineering. Project management, professional practice, ethical and engineering economic considerations and development of written and oral presentation skills. Provides laboratory experience in prototyping, fabrication, and troubleshooting of the design project. Stresses written and oral presentation.
**Prerequisites:** E&C-ENGR 402WI, RooWriter.

E&C-ENGR 412 Principles of RF/Microwave Engineering Credits: 3
General aspects of TE, TM and TEM mode propagation in waveguides; circular waveguides; optical waveguides; wave propagation on dielectric backed conductors; wire antennas; equivalence principle and aperture antennas; antenna impedance and mutual coupling in arrays; array beamforming; scattering matrix representations; impedance matching; resonators; filters, couplers and power-dividers; microstriplines and striplines; r.f. propagation in wireless and radar systems; conformal mapping techniques and applications (optional).
**Prerequisites:** E&C-ENGR 302, E&C-ENGR 380, E&C-ENGR 381, MATLAB proficiency.

E&C-ENGR 414 Microwave Engineering for Wireless Systems Credits: 3
Microwave networks; s-, z-, y- and abcd matrices; signal flow graphs; circular waveguides; stripline microstrip characteristics; impedance transformers; power dividers and directional couplers; microwave filters; microwave resonators; active microwave circuits.
**Prerequisites:** E&C-ENGR 302, E&C-ENGR 380, MATLAB proficiency.

E&C-ENGR 415 Microwave Engineering for Wireless Systems Lab Credit: 1
Design performance simulation of microwave filters and active microwave circuits; comparative analysis of impedance transformers; use of CAD tools in microwave circuit design.
**Prerequisites:** E&C-ENGR 414.
E&C-ENGR 416 Neural and Adaptive Systems Credits: 3
A hands-on introduction to the theory and applications of neurocomputing. Includes classification, function approximation, supervised and unsupervised learning, time series analysis, and adaptive filtering using different feed-forward and recurrent artificial neural networks.
Prerequisites: COMP-SCI 394R, E&C-ENGR 341R.

E&C-ENGR 418 Introduction to Radar Systems Credits: 3
Radar equation; MT, Pulsed Doppler and Tracking Radars; detection of and information from radar signals; radar antennas; transmitters and receivers; radar propagation and clutter.
Prerequisites: E&C-ENGR 302, E&C-ENGR 380, E&C-ENGR 381.

E&C-ENGR 420 Advanced Engineering Computation Credits: 2
Programming and computational analysis principles and techniques for various problems in embedded programming, applied computation, and signal processing.
Co-requisites: E&C-ENGR 428R and E&C-ENGR 429.

E&C-ENGR 424 Computer Design Credits: 3
Design of general purpose computers including arithmetic and control units, input/output, memory systems, microprogramming and introduction to parallel structures and processing.
Prerequisites: E&C-ENGR 226.

E&C-ENGR 426 Microcomputer Architecture and Interfacing Credits: 3
Advanced microprocessor architecture and programming; interfacing and programming of peripherals. Parallel and serial communication, interrupts, direct memory access, coprocessors.
Prerequisites: E&C-ENGR 226.

E&C-ENGR 427 Microcomputer Laboratory Credit: 1
Laboratory for E&C-ENGR 426. Microprocessor hardware and software involving interfacing of peripherals to 8-bit and 16-bit microprocessor. Simple D/A conversion, music composition, and various programmable controllers.
Prerequisites: E&C-ENGR 227.
Co-requisites: E&C-ENGR 426.

E&C-ENGR 428R Embedded Systems Credits: 3
This course examines the hardware/software aspects associated with developing microcontroller-based computer systems. The students learn about the architecture and assembly language for popular microcontrollers and how to take advantage of a variety of input/output options that include binary ports, A/D and D/A converters, communication ports, and interfacing techniques for various applications.
Prerequisites: E&C-ENGR 426, E&C-ENGR 427.
Co-requisites: E&C-ENGR 429.

E&C-ENGR 429 Embedded Systems Laboratory Credit: 1
The laboratory introduces the students to a variety of challenging design projects using microcontroller interfacing techniques to develop real world applications, such as digital thermometer and digital pressure monitoring systems. Students must produce an individual design project.
Prerequisites: E&C-ENGR 426, E&C-ENGR 427.
Co-requisites: E&C-ENGR 428R.

E&C-ENGR 430 Microelectronic Circuits Credits: 3
The analysis and design of feedback amplifiers, oscillators and of microelectronic circuits that employ diodes, MOSFETs and BJTs in current mirrors, amplifiers with active loads, differential amplifiers, operational amplifiers, and CMOS Logic gates. The use of CAD (Spice) in the analysis and design of feedback amplifiers and microelectronic circuits.
Prerequisites: E&C-ENGR 330, E&C-ENGR 331.
Co-requisites: E&C-ENGR 431.

E&C-ENGR 431 Microelectronic Circuits Laboratory Credit: 1
Laboratory experiments in the analysis, design and testing of feedback amplifiers; microelectronic circuits that employ diodes, MOSFETs and BJTs in feedback amplifiers, oscillators, current mirrors, amplifiers with active loads, differential amplifiers, operational amplifiers, and CMOS logic gates.
Prerequisites: E&C-ENGR 330, E&C-ENGR 331.
Co-requisites: E&C-ENGR 430.
E&C-ENGR 433 Analog Integrated Circuit Design Credits: 3
Principles of the design and analysis of analog integrated circuits. Study of MOS device physics and second order effects, device fabrication and layout, noise, single-stage and differential amplifiers, current mirrors, reference circuits, op amps and frequency compensation. Introduction to CAS circuit design and Cadence design tools.
Prerequisites: E&C-ENGR 276.

E&C-ENGR 436 Power Electronics I Credits: 3
Power electronic device characteristics, important circuit and component concepts, phase controlled rectifiers, line communicated inverters and AC phase control. Includes laboratory projects.
Prerequisites: E&C-ENGR 430.

E&C-ENGR 442 Introduction to VLSI Design Credits: 3
The goal of this course is to familiarize students with the design fundamentals and layout of Very Large Scale Integrated (VLSI) Circuits. The primary focus of this course is complementary MOSFET (CMOS) based digital integrated circuits design and analysis. However, the topics regarding transistor, interconnect, and circuit implementation are relevant to digital, analog and mixed-signal integrated circuits. This course is designed to be a comprehensive foundation for advanced micro- and nano-electronics courses. To familiarize the students with the realities of design complexities they will get exposure to commercial CAD tools in a separate lab co-requisite class. Recommended preparation: Basic Electronics.
Co-requisites: E&C-ENGR 443.

E&C-ENGR 443 Introduction to VLSI Design Laboratory Credits: 3
The goal of this course is to teach basic design concepts and implementation issues of digital integrated circuits. Various methods of designing and optimizing very large scale integrated (VLSI) circuits will be introduced in the lab projects. To familiarize students with the realities of integrated circuit design and layout, they will get exposure to industry-standard computer aided design (CAD) and simulation tools for VLSI circuits and systems. The students will be using these CAD tools in the following levels – schematic, layout, parasitic extraction, and circuit simulation.
Co-requisites: E&C-ENGR 442.

E&C-ENGR 454 Robotic Control and Intelligence Credits: 3
Introduces robotics; robot system characteristics; robot motive power systems; geometric structure of robots; sensors and feedback; control applications and algorithms; data acquisition and output actuation functions; robots and Artificial Intelligence; microprocessor applications in robotics.
Prerequisites: E&C-ENGR 226 (or E&C-ENGR 426), E&C-ENGR 358.

E&C-ENGR 455 Instrumentation and Control Credits: 3
The instrumentation and control of industrial processes and systems, introduction to Programmable Logic Controllers, and simulation modeling of various systems.
Prerequisites: E&C-ENGR 358.

E&C-ENGR 457 Fundamentals of Solar Photovoltaic Cells Credits: 3
The science and engineering of solar cell/solar photovoltaic (PV) spans several disciplines namely physics, chemistry, electronic and electrical engineering. Even though solar cell related researches are carried out in those traditional disciplines but it is not widely taught as a comprehensive course. This course highlights the fundamental science and engineering of solar PV devices, solar energy conversion as well as solar cell manufacturing issues. It covers from basic to modern solar PV devices, including typical solar cell materials, basic device physics, ideal and non-ideal models, device parameters and design, and device fabrication.

E&C-ENGR 458 Automatic Control System Design Credits: 3
Techniques for feedback system design analysis: compensator design examples, state variable methods, non-linear systems, and sampled-data control systems.
Prerequisites: E&C-ENGR 380, E&C-ENGR 358.

E&C-ENGR 459 Introduction to Photovoltaic Systems Credits: 3
The course presents an updated background of world energy production and consumption, a summary of the solar spectrum, how to locate the sun, and how to optimize the capture of its energy, as well as the various components that are used in PV systems. Also studied are why certain photovoltaic (PV) designs are used in certain ways, as well as how the design process is implemented. Economic and environmental issues involved in PV design criteria are discussed along with the most recently available technology, design, and installation practices.

E&C-ENGR 460 Introduction to Power Systems Credits: 3
Magnetic circuitry in general and in machinery; DC machine theory, operation, applications, transformer circuits, synchronous machine theory, operation applications, basic principles of energy conversion, introduction to power electronics, and basic principles of power transmission and control.
Prerequisites: E&C-ENGR 276.
E&C-ENGR 461 Electric Power Lab Credits: 3
Application of fundamentals and concepts of power systems to practical power plan and industrial applications. Operational limitations of all components of power system equipment. Single and Three Phase Circuits, Generators/Alternators, Transformers, Motors, and specialty items (Coronal mass Ejection, Ferroresonance, System Protection).
**Prerequisites:** E&C-ENGR 466.

E&C-ENGR 462 Symmetrical Components Analysis of Power Systems Credits: 3
Short circuit analysis using symmetrical components. Simultaneous faults and open conductors.
**Prerequisites:** E&C-ENGR 466.

E&C-ENGR 463 Advanced Sustainable Energy Systems Engineering Credits: 3
Sustainable Energy Systems Engineering focuses on understanding the theory and application of emerging energy technologies, including solar, wind, biomass, oceanic, geothermal, hydropower, fuel cell (hydrogen), nuclear, and other more exotic energy sources. A premise of the course is that a sustainable energy technology must both be technically feasible and economically viable. Renewable energy sources will be highlighted with a focus on projections for a sustainable energy future. Graduate students will be assigned an additional project to work.
**Prerequisites:** E&C-ENGR 466.

E&C-ENGR 465 Application of Engineering Principles to Station Design Credits: 3
Students will learn the application of engineering principles to circuits (transient and steady state responses), traveling waves, power system equipment, Lorentz forces, heat transfer, moments, load modeling, and written and oral communication. These will be applied to any of the following: a sub/switching station or an auxiliary electric system of a coal fired or combined cycle power plant. Requirements are agreed upon by an engineering firm who will sponsor this course by providing guidance.
**Prerequisites:** E&C-ENGR 466 with at least a B+ grade and Department Consent.

E&C-ENGR 466 Power Systems I Credits: 3
Electric power system fundamentals, rotating machines in general, synchronous, induction and DC machines, methods of power system analysis and design, modeling of power systems components such as transmission lines, transformers and generators, and analysis of steady state operation of power system under balanced conditions.
**Prerequisites:** E&C-ENGR 376.

E&C-ENGR 467 Power Systems II Credits: 3
**Prerequisites:** E&C-ENGR 358, E&C-ENGR 466.

E&C-ENGR 468 Electric Power Distribution Systems Credits: 3
Operation and design of utility and industrial distribution systems including distribution system planning; load characteristics; application of distribution transformers; design of subtransmission lines, distribution substations, primary systems, secondary systems; application of capacitors; voltage regulation and reliability.
**Prerequisites:** E&C-ENGR 466.

E&C-ENGR 470 Reliability of Electric Power Systems Credits: 3
Principles of reliability as applied to Power Systems with an overview of current methods to measure reliability of Power Systems are introduced. Analytical and Monte Carlo models for component system and state duration, with contingency analysis and linear programming for optimal power flow are also covered. Restoration times and cost assessment after component or system failures due to internal or external problems provide focus to practical operating principles.
**Prerequisites:** COMP-SCI 394R and E&C-ENGR 466.

E&C-ENGR 472 Power Generation Systems Credits: 3
Multi discipline survey of power generation systems and subsystems, including coal-fired steam, co-generation and combined cycle, and combustion turbines. With a goal of reviewing all the major subsystems, this course exposes the electrical engineer to all the mechanical, thermodynamic, and chemical processes of power generation systems.
**Prerequisites:** E&C-ENGR 466.

E&C-ENGR 474 Introduction to Communication Systems Credits: 3
Introduction to principles and fundamentals of communication systems. Signal representation and analysis, Fourier transform and applications, probability and random variables, analog and digital modulation techniques.
**Prerequisites:** COMP-SCI 394R, E&C-ENGR 380.

E&C-ENGR 476 Introduction to Wireless Communication Systems Credits: 3
Principles of wireless communication analysis and design. Digital communication basics, cellular radio, wireless PCS communications, multiple access techniques, channel coding and equalization, and standards of digital cellular/PCS systems.
**Prerequisites:** E&C-ENGR 474.
E&C-ENGR 477 Introduction to Wireless Networking Credits: 3
Principles of the design and analysis of wireless networks. Study of medium access control, administration routing and adaptation to the complexities of the wireless environment. Investigation of networking issues in the IEEE 802.11 family of standards, IEEE 802.15 (Bluetooth), Long Term Evolution, cellular, satellite, ad hoc, and sensor networks.
Prerequisites: COMP-SCI 394R.

E&C-ENGR 480 Digital Signal Processing Credits: 3
Concepts, analytic tools, design techniques used in computer processing of signals: signal representation, sampling, discrete-time system analysis, recursive/non-recursive filters, design/implementation of digital filters.
Prerequisites: E&C-ENGR 380.

E&C-ENGR 484 Digital Image Processing Credits: 3
Fundamentals of digital image processing hardware and software, including digital image acquisition, display, compression, transforms and segmentation. Recommended preparation: Experience in a high-level programming language.
Prerequisites: E&C-ENGR 380.

E&C-ENGR 486 Pattern Recognition Credits: 3
Pattern recognition techniques of applications such as automatic recognition for speech, visual inspection systems, clinical medicine, automatic photographic recognition systems and advanced automation systems.
Prerequisites: E&C-ENGR 380.

E&C-ENGR 491 Internship Credits: 6
Students may participate in structured internships under the joint supervision of an employer and a faculty member. The student must carry out significant professional responsibilities that also have academic merit. The number of credit hours is based on the quality of the academic experience. Available for credit/no credit only and students must be in good standing with at least 18 credit hours of EC-ENGR courses counting towards the degree. Registration by consent number only; petition forms for E&C-ENGR 491 internships are available in the office of CSEE Division and on the web.
Prerequisites: At least 18 hours of EC-ENGR courses toward the degree.

E&C-ENGR 497 Directed Readings Credits: 1-4
Readings in an area selected by an undergraduate student in consultation with a faculty member. Arrangements must be made prior to registration.

E&C-ENGR 499 Undergraduate Research Credits: 1-3
Completion of a project, including a final written report, under the direction of a faculty member. A prospectus must be accepted prior to registration.

E&C-ENGR 5316 Artificial Neural and Adaptive Systems Credits: 3
This graduate course is a hands-on introduction to theory and applications of neurocomputing, including: classification, function approximation, supervised and unsupervised learning, time series analysis, and adaptive filtering using different feed-forward and recurrent artificial neural networks.
Prerequisites: E&C-ENGR 341R (or COMP-SCI 5590CI).

E&C-ENGR 5512 Microwave Remote Sensing Credits: 3
Basic principles of remote sensing including scattering, absorption, transmission, and reflection of microwave energy. Basic radiative transfer theory. Microwave remote sensing systems including altimeters, scatterometers, radiometers, synthetic-aperture systems. Principle applications of remote sensing systems including imaging, atmospheric sounding, oceanographic monitoring, ice-sheet dynamics, etc.
Prerequisites: E&C-ENGR 414.

E&C-ENGR 5513 Advanced Principles of RF/Microwave Engineering Credits: 3
General aspects of TE, TM and TEM mode propagation in waveguides; circular waveguides; optical waveguides; wave propagation on dielectric backed conductors; wire antennas equivalence principle and aperture antennas; antenna impedance and mutual coupling in arrays; array beamforming; scattering matrix representations; impedance matching; resonators; filters, couplers and power-dividers; microstrip lines and striplines; r.f. propagation in wireless and radar systems; conformal mapping techniques ad applications (optional).
Prerequisites: E&C-ENGR 302, E&C-ENGR 380, E&C-ENGR 381, knowledge in Engineering Computation, Technical Writing Skills.
E&C-ENGR 5516 Computer Networks Credits: 3
Concepts and goals of computer networking, structure of computer networks, OSI model and layers, network control, analysis, design and management, data communication techniques including fiber optics, WAN, MAN and LAN architecture and protocols, internetworking, case studies and hand-on studying the performance by analytic modeling and computer simulation.
Prerequisites: E&C-ENGR 424.

E&C-ENGR 5518 Advanced Radar Systems & Techniques Credits: 3
Radar equation; MTI, Pulsed Doppler and Tracking Radars; Detection of and information from Radar Signals; Radar Antennas, Transmitters and Receivers; Radar Propagation and clutter.
Prerequisites: E&C-ENGR 302, E&C-ENGR 380.

E&C-ENGR 5528 Advanced Embedded Systems Credits: 3
This course examines the hardware/software aspects associated with developing microcontroller-based computer systems. The students learn about the architecture and assembly language for popular microcontrollers and how to take advantage of a variety of input/output options that include binary ports, A/D and D/A converters, communication ports, and interfacing techniques for various applications. Graduate students are required to do Embedded Systems lab experiments.
Prerequisites: E&C-ENGR 426, E&C-ENGR 427.

E&C-ENGR 5530 Digital Electronics Credits: 3
Electronic hardware aspects of digital systems. Includes state-of-the-art information on integrated-circuit logic devices and their applications.

E&C-ENGR 5532 Biomedical Instrumentation Credits: 3
Biomedical objectives, physical and engineering principles; optimal equipment design and actual performance of biomedical instrumentation; considers practical instrumentation problem solutions and unsolved problems.
Prerequisites: E&C-ENGR 330.

E&C-ENGR 5533 Analog Integrated Circuit Design Credits: 3
This course will cover the analysis and design of analog and mixed signal integrated circuits, with an emphasis on design principles for realizing state-of-the-art analog circuits. The course will provide the critical concepts by giving physical and intuitive explanations in addition to the quantitative analysis of important analog building block circuits. First-order hand calculations and extensive computer simulations are utilized for performance evaluation and circuit design. Students will be required to complete a final project which will involve the design at the layout level of an analog circuit. Successful designs will be fabricated through the MOSIS Educational Service.
Prerequisites: E&C-ENGR 276, E&C-ENGR 330.

E&C-ENGR 5534 Computer Arithmetic Credits: 3
Computer arithmetic is a sub field of digital computer organization. It deals with the hardware realization of arithmetic functions to support various computer architectures as well as with arithmetic algorithms for firmware/software implementation. A major thrust of digital computer arithmetic is the design of hardware algorithms and circuits to enhance the speed of various numeric operations. Verilog HDL is used as tool to simulate the algorithms and circuits.
Prerequisites: E&C-ENGR 226, E&C-ENGR 5535.

E&C-ENGR 5535 Hdl-Based Digital Systems Design Credits: 3
This course covers hardware design techniques using a Hardware Description Language (HDL). It also discusses several digital system design methodologies, including structural specifications of hardware, HDL-based simulations and testbenches. Courses focus on the synthesis methodologies for use-defined primitives (UPD), data types, operators, Verilog constructs multiplexed datapaths, buses, bus drivers, FSMs, assignments, case, functions, tasks, named events and rapid prototyping techniques with Verlog HDL, ASICs and FPGAs.
Prerequisites: E&C-ENGR 226.

E&C-ENGR 5536 Power Electronics II Credits: 3
Circuit concepts and analysis techniques for transistor switching regulators, thyristor choppers, transistor inverters, self-commutated thyristor inverters and cycloconverters.
Prerequisites: E&C-ENGR 436.

E&C-ENGR 5537 Mixed-Signal Integrated Circuit Design Credits: 3
Modern integrated circuit design often requires the integration of analog and digital circuits on the same chip. This integration provides numerous advantages over purely analog or digital approaches. This course will cover the analysis and design of mixed-signal integrated circuits and will address the challenges of having both analog and digital circuits on the same substrate. Important mixed-signal circuits such as data converters and filters will be studied in detail.
Prerequisites: E&C-ENGR 433 (or E&C-ENGR 5533).
E&C-ENGR 5542 Introduction to VLSI Design Credits: 3
With a focus on CMOS Digital technology this course covers the basic concepts of integrated circuits, various methods of designing VLSI circuits, and techniques to analyze performance metrics (speed, area, power and noise). Clocking, interconnect and scaling issues of integrated circuit will also be discussed. It will cover device, interconnect and circuit level implementation issues of both logic and memory circuits. To familiarize students with the realities of design complexities and layout environment they will get exposure to VLSI CAD tools in the following levels - schematic, layout, extraction and circuit simulation through the labs and projects.

E&C-ENGR 5556 Advanced Instrumentation and Control Credits: 3
The instrumentation and control of industrial processes and systems. Introduction to Programmable Logic Controllers. Simulation modeling of various systems.
Prerequisites: E&C-ENGR 358 (or MEC-ENGR 415).

E&C-ENGR 5557 Fundamentals of Solar Photovoltaic Cells Credits: 3
The science and engineering of solar cell/solar photovoltaic (PV) spans several disciplines namely physics, chemistry, electronic and electrical engineering. Even though solar cell related researches are carried out in those traditional disciplines but it is not widely taught as a comprehensive course. This course highlights the fundamental science and engineering of solar PV devices, solar energy conversion as well as solar cell manufacturing issues. It covers from basic to modern solar PV devices, including typical solar cell materials, basic device physics, ideal and non-ideal models, device parameters and design, and device fabrication.

E&C-ENGR 5558 Automatic Control System Design Credits: 3
Techniques for feedback system design and analysis; computational aids, compensator design and examples, state variable methods, non-linear systems, ad sampled-data control systems.
Prerequisites: E&C-ENGR 226, E&C-ENGR 358.

E&C-ENGR 5559 Introduction to Photovoltaic Systems Credits: 3
The course presents an updated background of world energy production and consumption, a summary of the solar spectrum, how to locate the sun and how to optimize the capture of its energy, as well as the various components that are used in PV systems. Some section of the course has also been added to explain why certain photovoltaic (PV) designs are done in certain ways, as well as how the design process is implemented. Economic and environmental issues as PV design criteria are discussed along with the most recently available technology and design and installation practice.

E&C-ENGR 5560 Electric Power Distribution Systems Credits: 3
Operation and design of utility and industrial distribution systems including distribution system planning; load characteristics; application of distribution transformers; design of subtransmission lines, distribution substations, primary systems, secondary systems, Smart Grid; application of capacitors; voltage regulation and reliability.
Prerequisites: E&C-ENGR 466.

E&C-ENGR 5563 Sustainable Energy System Engineering Credits: 3
This course focuses on understanding the theory and application of emerging energy technologies, including solar, wind, biomass, oceanic, geothermal, hydropower, fuel cell (hydrogen), nuclear, and other more exotic energy sources. A premise of the course is that a sustainable energy technology must both be technically feasible and economically viable. We consequently investigate the above energy technologies and the technological promise, progress, and application of each energy source, as well as its economic opportunities and challenges. Renewable energy sources will be highlighted with a focus on projections for a sustainable energy future.

E&C-ENGR 5565 Auxiliary Electric System Design Credits: 3
This course provides design, operation, contingency analysis and black start requirements of an Auxiliary Electric System (AES) for a coal fired power plant using industry standards (IEEE-666, NEMA MG-1, ANSI C57 and C37 as well as relevant IEC).
Prerequisites: E&C-ENGR 466 or Department Approval.

E&C-ENGR 5567 Power Systems II Credits: 3
This course covers power system matrices, power flow analysis, Gauss-Seidel and Newton-Raphson techniques, fast-decoupled load flow, economic dispatch, transient stability and operation, and power system control.
Prerequisites: E&C-ENGR 358, E&C-ENGR 466.

E&C-ENGR 5568 Economics of Power Systems Credits: 3
Transmission loss formula coefficients, incremental costs and losses, economic scheduling of generation, and applications.
Prerequisites: E&C-ENGR 466, E&C-ENGR 467.

E&C-ENGR 5569 Reliability of Electric Power Systems Credits: 3
Development and use of mathematical models for the calculation and estimation of various measures of reliability in electric power systems, Reliability restoration times and cost assessment of generation, transmission, distribution and composite systems are analyzed.
Prerequisites: COMP-SCI 394R.
E&C-ENGR 5570 Principles of Digital Communication Systems Credits: 3
Principles of random processes, information sources and source coding, modulation and demodulation, block and convolutional error control coding, and equalization.
Prerequisites: COMP-SCI 394R (or equivalent), E&C-ENGR 380.

E&C-ENGR 5572 Antennas & Propagation For Wireless Systems Credits: 3
This course introduces the mathematical aspects of the basic antenna parameters such as vector potential, gain, directivity, impedance, radiation patterns, and develops a comprehensive theory of antenna arrays including the effects of mutual coupling. In-depth modeling studies for wire, aperture and microstrip antennas, is presented; diffraction of plane electromagnetic (TE and TM) waves by perfectly conducting half-planes and wedges- applications to site-specific propagation path modeling in wireless systems.
Prerequisites: E&C-ENGR 341R (or equivalent), E&C-ENGR 412 (or equivalent), written communication skills.

E&C-ENGR 5573 Advanced Electric Power Lab Credits: 3
Advanced applications of concepts experienced in Generating Plants, Substations and Power Plants of fundamentals and concepts of power systems to practical power plan and industrial applications. Operational limitations of all components of power system equipment. Single and Three Phase Circuits, Generators/Alternators, Transformers, Motors, and specialty items (Coronal mass Ejection, Ferroresonance, System Protection).
Prerequisites: E&C-ENGR 466 (or equivalent) and Consent of the Department.

E&C-ENGR 5577 Wireless Communications Credits: 3
Principles of the design and analysis of wireless communications, Study of propagation mechanisms, statistical characterization of wireless channels, diversity and MIMO, spread spectrum and CDMA, Orthogonal Frequency Division Multiplexing (OFDM).
Prerequisites: COMP-SCI 394R (or equivalent).

E&C-ENGR 5578 Multimedia Communication Credits: 3
Visual communication is dominating the Internet and mobile networks. This class covers topics on video signal processing, modeling, compression, and communication. Includes information theory foundations on source coding, lossless coding schemes, video coding framework, as well as the current status of video coding standards and multimedia communication systems.

E&C-ENGR 5579 Digital Signal Processing in Telecommunications Credits: 3
Applications of digital signal processing in telecommunications systems; oversampling and quantization, Delta-Sigma modulation, linear predictive speech coding, adaptive filtering, echo canceller, adaptive receivers and equalizers for wireless communication, digital cellular, CDMA.
Prerequisites: E&C-ENGR 474, E&C-ENGR 480.

E&C-ENGR 5580 Digital Signal Processing Credits: 3
Analysis and representation of discrete-time signals and systems including a discussion of discrete-time convolution, difference equations, the z-transform and the discrete Fourier transform. Similarities with and distinctions between discrete-time and continuous-time signals and systems. Digital network structures for implementation of both recursive (infinite impulse response) and nonrecursive (finite impulse response) digital filters. FFT (Fast Fourier Transform) algorithm for computation of the discrete Fourier transform. Graduate students will be expected to successfully complete a number of additional projects as compared with E&C-ENGR 480.
Prerequisites: E&C-ENGR 380.

E&C-ENGR 5582 Image Analysis and Retrieval Credits: 3
Image is an essential form of information representation and communication in modern society with many applications ranging from photography, entertainment, education, defence to medical. A good understanding of the vast amount of image content at signal, image formation, syntactic and semantic levels, would be essential to create new capability and enabling new applications. The course is project based, teaching both theory and practical algorithm and system solutions for image formation/representation, analysis/understanding, image features computing and aggregation, indexing, hashing, and retrieval, as well as applications in mobile visual search, augmented reality and image based navigation.
Prerequisites: E&C-ENGR 5580 or equivalent.

E&C-ENGR 5584 Advanced Digital Image Processing Credits: 3
Fundamentals of applied grayscale digital image processing, image sensing and acquisition and quantization, basic set and discrete convolution operations with images, intensity transformations and spatial domain filtering via convolutional masks (smoothing, Laplacian and gradient masks), frequency domain filtering via the two-dimensional discrete transform, two-dimensional sampling and Nyquist theory, frequency domain filtering using lowpass/highpass, rectangular, round, Guassian and Butterworth filters, image restoration using noise filtering via mean order-statistic and adaptive filters, bandpass, band reject and notch filters, Weiner filters, image deblurring filters, computed aided tomography (i.e. CAT scans), morphological image processing and image segmentation.
Prerequisites: E&C-ENGR 380 (Or equivalent undergraduate course in signal processing) and prior experience with MATLAB.

E&C-ENGR 5586 Pattern Recognition Credits: 3
Decision functions, distance measures, minimum distance classifiers, hard clustering methods, fuzzy clustering methods, statistical pattern recognition methods, Bayesian classifiers, error probabilities, estimation of density functions, perceptrons, least-mean-square algorithms, feature selection, dimensionality reduction and syntactic pattern recognition.
Prerequisites: COMP-SCI 394R (or STAT 436), a course in high-level programming language.
E&C-ENGR 5588 Communication Theory I Credits: 3
Generalized communication systems, signal processing, signals as random processes, optimum receivers.
Prerequisites: COMP-SCI 394R, a statistics course.

E&C-ENGR 5590 Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5590AC Special Topics in Electrical and Computer Engineering Credits: 1-4
E&C-ENGR 5590AD Special Topics in Electrical and Computer Engineering Credits: 1-4
Special Topics in Electrical and Computer Engineering
E&C-ENGR 5590AE Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5590AN Special Topics in Electrical and Computer Engineering Credits: 1-4
E&C-ENGR 5590AR Special Topics in Electrical and Computer Engineering Credits: 1-4
Special Topics in Electrical and Computer Engineering
E&C-ENGR 5590AS Special Topics in Electrical and Computer Engineering Credits: 1-4
E&C-ENGR 5590AV Special Topics in Electrical and Computer Engineering Credits: 1-4
E&C-ENGR 5590AW Special Topics in Electrical and Computer Engineering Credits: 1-4
E&C-ENGR 5590B Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5590BB Special Topics in Electrical and Computer Engineering Credits: 1-4
E&C-ENGR 5590BE Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5590BI Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5590BP Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5590C Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5590CA Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5590CD Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5590CI Special Topics in Electrical and Computer Engineering Credits: 1-4
E&C-ENGR 5590CL Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5590CN Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5590CS Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5590CT Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5590DC Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5590DE Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5590DS Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5590EN Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5590ER Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5590ES Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5590ET Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5590FC Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5590HF Special Topics In Electrical and Computer Engineering Credits: 1-4
E&C-ENGR 5590IC Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5590IE Special Topics Credits: 1-4
E&C-ENGR 5590IN Special Topics In Electrical And Computer Engineering Credits: 1-4
Special Topics In Electrical And Computer Engineering
E&C-ENGR 5590IP Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5590IR Special Topics in Electrical and Computer Engineering Credits: 1-4
E&C-ENGR 5590MC Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5590ML Special Topics In Electrical And Computer Engineering Credits: 1-4
Special Topics In Electrical And Computer Engineering
E&C-ENGR 5590MS Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5590MW Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5590NA Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5590NG Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5590NM Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5590NN Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5590NR Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5590NT Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5590ON Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5590OT Special Topics in Electrical and Computer Engineering Credits: 1-4
E&C-ENGR 5590PB Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5590PD Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5590PG Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5590PL Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5590PL2 Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5590PL3 Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5590PQ Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5590PR Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5590PS Special Topics in Electrical and Computer Engineering Credits: 1-4
E&C-ENGR 5590PV Special Topics in Electrical and Computer Engineering Credits: 1-4
E&C-ENGR 5590RD Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5590RE Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5590RF Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5590SC Special Topics in Electrical and Computer Engineering Credits: 1-4
E&C-ENGR 5590SD Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5590SI Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5590SL Special Topics in Electrical and Computer Engineering Credits: 1-4
E&C-ENGR 5590SP Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5590ST Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5590TC Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5590VL Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5590WC Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5590WW Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5590WX Special Topics Credits: 1-3
E&C-ENGR 5590XX Special Topics In Electrical And Computer Engineering Credits: 1-4
E&C-ENGR 5597 Directed Readings Credits: 1-3
Readings in an electrical and computer engineering areas selected by the graduate student in consultation with a faculty member. Arrangements must be made prior to registration.
E&C-ENGR 5598 Research Seminar Credits: 1-3
Graduate research and/or readings in an electrical and computer engineering area selected by the graduate student in consultation with a faculty member. Arrangements must be made prior to registration.
E&C-ENGR 5599 Research Credits: 1-6
Independent investigation in field of electrical engineering to be presented in the form of a thesis.
E&C-ENGR 5600 Problems Credits: 2-5
Supervised investigation in electrical engineering to be presented in form of report.
E&C-ENGR 5606 Electromagnetic Scattering and Antenna Theory Credits: 3
Dyadic analysis; integral equations and Green's functions; field theorems-uniqueness, induction equivalence, reciprocity; image and Babinet's Principles; applications to antennas; method of stationary phase and applications to aperture antennas; array antennas and mutual coupling analysis; method of moments; asymptotic techniques and applications to EM scattering from wedges, cylinders, and spheres; RF propagation path loss modeling and conformal antennas.
Prerequisites: E&C-ENGR 412.

E&C-ENGR 5616 Parallel and Distributed Processing Credits: 3
Covers the fundamental issues involved in designing and writing programs for simultaneous execution. Semaphores and monitor constructs are covered to provide a basis for critical section programming. Expansion of these concepts provide a basis for the analysis and design of control systems for multiprocessor devices and computer networks.
Prerequisites: A systems programming course.

E&C-ENGR 5617 Neural Network Based Computing System Credits: 3
The course will consider computing systems based on neural networks and learning models, along with implementations and applications of such systems.

E&C-ENGR 5618 Artificial Intelligence Credits: 3
Concepts, theories, and models pertaining to neural nets, pattern recognition, learning systems, and programmed problem solving.

E&C-ENGR 5619 Theory of Automata Credits: 3
Sequential machines: Turing machines; deterministic and stochastic automata; applications of automata.

E&C-ENGR 5624 Digital Software Systems Design Credits: 3
Characteristics and parameters of various software subsystem including assemblers, compilers, utility programs, special programming packages, interpreters, and operating systems; and principles of organization into efficient systems.

E&C-ENGR 5633 Nanoelectronics II: Nanoscale Integration & Manufacturing Credits: 3
This course is continuation of Nanoscale Devices and circuits course offered in Fall 2016. In this course students will learn theory about semiconductor processing, and their applications. Limitations of existing process techniques will be discussed, and advances in both physical implementation and circuit/integration techniques will be introduced. Some example of topics that will be covered are: optical lithography, EUV lithography, nanoimprint, implantation, manufacturing aware circuit design, etc. The laboratory work will include modeling and simulation with state-of-the-art semiconductor processing and device simulation tools such as: SRIM, Sentaurus TCAD Process, Sentaurus TCAD Device, etc. Research intensive course.
Co-requisites: E&C-ENGR 5542.

E&C-ENGR 5655 VLSI Systems Design Credits: 3
Course discuss design of the MOSFETs (nFETs and pFETs), and high speed CMOS cascades in VLSI. It also covers the design of various arithmetic circuits, different fast adders, memories, and chip-level physical designs requirements in the VLSI subsystems are also the focus of this course. It uses Verilog HDL/VHDL as a tool to design VLSI systems.
Prerequisites: E&C-ENGR 5535 (or knowledge of VHDL).

E&C-ENGR 5642 Advanced VLSI Design Credits: 3
Course focuses on the issues and challenges of high performance VLSI circuits and systems. The course will be based on papers published in accredited journals and conference proceedings. The goals of this course: (1) Familiarize students with the current and emerging trends, issues and design alternatives of deep submicron and nanoscale IC technologies; (2) Help students acquire the knowledge and skills required for graduate study and research, and professional careers in IC industry; and (3) Teach students how to collect and survey technical materials, develop new research ideas, write research papers, and present technical contents in front of an audience.

E&C-ENGR 5644 Liapunov and Related Nonlinear Methods in Automatic Control Credits: 3
A study of nonlinear methods in automatic control including phase plane analysis, describing function techniques, basic definitions and theorems of Liapunov, methods of generating Liapunov functions, applications of Liapunov's methods, and Popov's methods.

E&C-ENGR 5645 Optimal Control Theory Credits: 3
Analysis and design of dynamic systems using optimal control theory parameter optimization, dynamic optimization, computational methods, differential games.

E&C-ENGR 5646 Stochastic Optimal Estimation and Control Credits: 3
Surveys random process theory; stochastic control and optimization; estimation and filtering based on Kalman-Bucy techniques; stochastic stability; adaptive and learning control systems.

E&C-ENGR 5660 Power-Systems Stability Credits: 3
Performance of synchronous machines under transient conditions, power system stability, system fault computations using symmetrical components; computer solutions of power system problems.

E&C-ENGR 5661 Solid State Energy Conversion Credits: 3
Solid state direct energy conversion; and design of thermoelectric generators and heat pumps.
E&C-ENGR 5662 Power Electronic Drives Credits: 3
Advanced study of dc and ac motor drives controlled by power electronic methods, including phase controlled rectifier de chopper, cycloconverter, variable frequency inverters.
Prerequisites: E&C-ENGR 5536.

E&C-ENGR 5664 Lightning and Switching Surges in Power Systems Credits: 3
Overvoltage, switching surge and lightning effects of a power system. Use of grounding and lightning arresters. Effects of surges off and on machines.
Prerequisites: E&C-ENGR 466 (or equivalent), E&C-ENGR 467 (or equivalent).

E&C-ENGR 5668 Advanced Computer Methods in Power System Analysis Credits: 3
Prerequisites: E&C-ENGR 466, strong background in FORTRAN or C.

E&C-ENGR 5670 Direct Current Power Systems Credits: 3
Characteristic and performance analysis of DC transmission lines and associated conversion systems.

E&C-ENGR 5672 Power Systems Relaying Credits: 3
Theory of relaying systems for power system protection, improvement of power system stability. Relay coordination; performance of relays during transient swings and out-of-step conditions.
Prerequisites: E&C-ENGR 466.

E&C-ENGR 5674 Machine Intelligence Credits: 3
Formal languages in relation to natural language processing; formal languages, graphs, and image processing; formal logic and automated theorem proving; natural language processing; aspects of problem solving and heuristic programming.

E&C-ENGR 5675 Introduction to the Modeling and Management of Uncertainty Credits: 3
Theoretical and practical issues in the modeling and management of uncertainty. Topics include probabilistic uncertainty, belief theory and fuzzy set theory. Applications to computer vision, pattern recognition and expert systems.

E&C-ENGR 5676 Advanced Electric Circuit Analysis Credits: 3
Specialized study of mathematical analysis as applied to solutions of circuit networks with fixed and variable parameters.

E&C-ENGR 5677 Network Synthesis Credits: 3
Surveys linear active and nonreciprocal circuit elements, reliability conditions, methods for synthesizing active networks, and practical applications.
Prerequisites: E&C-ENGR 5676.

E&C-ENGR 5680 Digital and Sample-Data Systems Credits: 3
Introduces sampling and quantization, design of digital and sample-data systems, digital filters, adaptive sampling and quantization.
Prerequisites: E&C-ENGR 480.

E&C-ENGR 5681 Applications Of Transforms Credits: 3
Applications of Laplace and other transform methods of solution of circuit and field problems.

E&C-ENGR 5682 Coding Theory II Credits: 3
Further study of error-correcting codes; ring and cyclic codes, linear switching circuits, burst error codes, codes for arithmetic units, etc.
Prerequisites: E&C-ENGR 5579.

E&C-ENGR 5684 Computer Vision Credits: 3
Image processing methods for segmentation, object representation, scene description and scene interpretation.
Prerequisites: E&C-ENGR 484.

E&C-ENGR 5688 Communication Theory II Credits: 3
Probability theory of analog and digital communication in the presence of random process noise. Encoding systems, detection systems, optimum receivers.
Prerequisites: E&C-ENGR 472.

E&C-ENGR 5690 Advanced Topics In Electrical And Computer Engineering Credits: 1-4

E&C-ENGR 5690EM Advanced Topics In Electrical And Computer Engineering Credits: 1-4

E&C-ENGR 5690ET Advanced Topics In Electrical And Computer Engineering Credits: 1-4

E&C-ENGR 5690ND Special Topics in Electrical and Computer Engineering Credits: 1-3

E&C-ENGR 5697 Advanced Directed Readings Credits: 1-5
Advanced readings in an electrical and computer engineering area selected by the graduate student in consultation with a faculty member. Arrangements must be made prior to registration.
E&C-ENGR 5698 Advanced Research Seminar Credits: 1-5
Advanced Graduate research and/or readings in an electrical and computer engineering area selected by the doctoral student in consultation with a faculty member. Arrangements must be made prior to registration.

E&C-ENGR 5699 Dissertation Research Credits: 1-9
Doctoral Dissertation

Information Technology Courses
INFO-TEC 222 Multimedia Production and Concepts Credits: 3
Multimedia production and concepts will give an overview of multimedia technology and communication theory needed to deliver information and to produce interactive presentations for the web, portable media, and for in-person presentations and demos. The course offers exposure to software, hardware, other multimedia technologies, authoring and copyright matters.
Prerequisites: COMP-SCI 101.

INFO-TEC 290 Special Topics Credits: 1-3
Selected topics in specific subject areas of Information Technology which are not part of the regular offerings.

INFO-TEC 321 Introduction to Computing Resources Administration Credits: 3
This introductory course is designed to give an overview of a wide variety of technical, interpersonal, documentation, and managerial skills needed to become an effective systems administrator.
Prerequisites: COMP-SCI 201R.

INFO-TEC 350 Object-Oriented Software Development Credits: 3
Application of object oriented programming languages as a means to implement object oriented designs. Polymorphism through inheritance and interfaces, design methods such as Responsibility Driven Design and such reusable design techniques as abstract classes and frameworks. Event-driven programming and the Java Swing classes for constructing interactive Graphical User Interfaces (GUIs), the basics of the Unified Modeling (UML) and elementary design patterns.
Prerequisites: COMP-SCI 303.

INFO-TEC 426 Practical Network Security Credits: 3
This course examines common threats to computer network security and discusses various techniques to mitigate those threats. The course material is supplemented with lab assignments that implement network security tools and use them to build a small secure network. It discusses information hiding, traffic monitoring and control, intrusion detection, and security policy. Note: NOT FOR GRADUATE CREDIT.
Prerequisites: COMP-SCI 420.

INFO-TEC 427 Network Analysis Credits: 3
This course focuses on routing in an autonomous system network using Cisco Systems equipment. It will include a review of the fundamental operations needed in AS routing and will then, through lecture and lab assignments, implement various network configurations using Cisco equipment. The concepts addressed will include router, switch and protocol implementations for Cisco Discovery Protocol, Spanning Tree Protocol, VLAN’s, VLAN Trunking Protocol and standard Cisco network routing protocols, among others.
Prerequisites: COMP-SCI 420, INFO-TEC 321.

INFO-TEC 429 Introduction to Cybersecurity Credits: 3
This course introduces students to cybersecurity and its domains. The course will cover topics such as cryptography, software development security, access control, security architecture, security operations, disaster recovery, and physical and environmental security.
Prerequisites: INFO-TEC 321.

INFO-TEC 490 Special Topics Credits: 1-3
Selected topics in specific areas of Information Technology/ Computer Science. May be repeated for credit when the topic varies.

INFO-TEC 490A Special Topics Credits: 1-3
Selected topics in specific areas of Information Technology/ Computer Science. May be repeated for credit when the topic varies.

INFO-TEC 490C Special Topics Credits: 1-3
Selected topics in specific areas of Information Technology/ Computer Science. May be repeated for credit when the topic varies.

INFO-TEC 490DC Introduction to Data Compression Credits: 3
This course provides an introduction to information theory, first-order entropy; lossless methods such as Huffman coding, arithmetic coding, and dictionary methods; and lossy and transform coding including image, audio, and video formats. The emphasis in this course is on algorithmic understanding and applications rather than derivation from first principles. Not for graduate credit.
Prerequisites: MATH 210, COMP-SCI 303, or equivalent.

INFO-TEC 490GP Special Topics Credits: 1-3
Selected topics in specific areas of Information Technology/ Computer Science. May be repeated for credit when the topic varies.

INFO-TEC 490IT Special Topics Credits: 1-3
Selected topics in specific areas of Information Technology/ Computer Science. May be repeated for credit when the topic varies.
INFO-TEC 490J Special Topics Credits: 1-3
Selected topics in specific areas of Information Technology/Computer Science. May be repeated for credit when the topic varies.

INFO-TEC 490JU Special Topics Credits: 1-3
Selected topics in specific areas of Information Technology/Computer Science. May be repeated for credit when the topic varies.

INFO-TEC 490MI Special Topics Credits: 1-3
Selected topics in specific areas of Information Technology/Computer Science. May be repeated for credit when the topic varies.

INFO-TEC 490NA Special Topics Credits: 1-3
Selected topics in specific areas of Information Technology/Computer Science. May be repeated for credit when the topic varies.

INFO-TEC 490NS Special Topics Credits: 1-3
Selected topics in specific areas of Information Technology/Computer Science. May be repeated for credit when the topic varies.

INFO-TEC 490SD Special Topics Credits: 1-3
Selected topics in specific areas of Information Technology/Computer Science. May be repeated for credit when the topic varies.

INFO-TEC 490WD Special Topics Credits: 1-3
Selected topics in specific areas of Information Technology/Computer Science. May be repeated for credit when the topic varies.

INFO-TEC 491 Internship Credits: 1-6
Students may participate in structured internships under the joint supervision of an employer and a faculty member. The student must carry out significant professional responsibilities that also have academic merit. The number of credit hours is based on the quality of the academic experience. Available for credit/no credit only, and students must be in good standing with at least 18 credit hours of CS/IT counting towards the degree.

Prerequisites: Departmental consent.

**Mechanical Engineering Courses**

MEC-ENGR 130 Engineering Graphics Credits: 3
Introduction to Engineering Graphics with the use of the Computer Aided Design tools AutoCAD and SolidWorks. Introduction to 2D design with AutoCAD includes: basic features, layer control, geometric constructions, orthographic projections, dimensioning and notes, tolerancing, section views, and working drawings. Introduction to 3D design with SolidWorks includes: part modeling, revolved features, sweeps, lofts, assembly modeling and engineering drawings. No previous 2D or 3D CAD experience is necessary to take this class.

MEC-ENGR 130L Engineering Graphics Lab Credits: 0
Supplemental lab instruction and assistance for MEC-ENGR 130.

MEC-ENGR 131 Engineering Graphics-3D design Credit: 1
Introduction to Engineering Graphics using the 3D Computer Aided Design tool SolidWorks. Introduction to 3D design with SolidWorks includes: part modeling, revolved features, sweeps, lofts, assembly modeling, and engineering drawings. Some previous 2D AutoCAD experience is required to take this class. NOTE: This class starts halfway through the semester by joining in with MEC-ENGR 130 when they finish AutoCAD and begin SolidWorks.

Prerequisites: 2D AutoCAD experience.

MEC-ENGR 219 Computer Programming for Engineers Credits: 3
Analysis and synthesis of structured computer algorithms for solving engineering problems using high level programming tools such as Excel, Matlab, Fortran and/or C++.

Prerequisites: MATH 266.

MEC-ENGR 220 Electric Circuits Credits: 3
Introduction to electric circuits for civil and mechanical engineering students.

Prerequisites: MEC-ENGR 219, PHYSICS 250.

Co-requisites: MEC-ENGR 272.

MEC-ENGR 270 Engineering Analysis I Credits: 3
This is an applied course with emphasis on physics and engineering applications. Topics include engineering applications using conics, parametric equations, polar coordinates, vectors, solid analytic geometry, vector valued functions, multi-variable functions, partial derivatives (including applications), multiple integration, vector calculus including Green's Theorem, Curl and Divergence, line and surface integrals and Stoke's Theorem.

Prerequisites: MATH 268.

MEC-ENGR 272 Engineering Analysis II Credits: 3
An applied course using differential equations in solutions to engineering problems. Topics include applications in first-order differential equations, linear higher-order equations, Laplace transform, Series solutions of linear ODEs (Taylor, Power, and Fourier), Numerical solutions, introduction to systems of differential equations.

Prerequisites: MATH 268.
MEC-ENGR 285 Engineering Dynamics Credits: 3
Fundamentals of engineering dynamics, including kinematics and kinetics of particles and rigid bodies. Analysis based on forces and accelerations as well as energy and momentum methods.
Prerequisites: CIV-ENGR 275.

MEC-ENGR 299 Engineering Thermodynamics Credits: 3
Fluid properties, work and heat, first law, second law, entropy, applications to vapor and ideal gas processes.
Prerequisites: MATH 268, PHYSICS 250.

MEC-ENGR 301 Fundamental Topics in Mechanical Engineering Credits: 3
Current and new technical developments in mechanical engineering.

MEC-ENGR 306 Computer-Aided Engineering Credits: 3
Prerequisites: CIV-ENGR 319, MEC-ENGR 272.

MEC-ENGR 324 Engineering Materials Credits: 3
The nature of the structure of engineering materials. The relationship of material structure to the physical properties. Mechanical behavior of engineering materials.
Prerequisites: CHEM 211, CHEM 211L, CIV-ENGR 276.

MEC-ENGR 351 Fluid Mechanics Credits: 3
Concepts of the statics and dynamics of fluids, with emphasis on principles of continuity, momentum and energy. Boundary layers, dimensional analysis and drag are covered briefly. Thorough treatment of pipe flow.
Prerequisites: MATH 250 or MEC-ENGR 270, and MEC-ENGR 272.

MEC-ENGR 352 Mechanical Instruments Lab Credits: 2
Students will investigate random and systematic errors, and their effects on measurement uncertainty. Students will be introduced to various instrumentation equipment used in measuring displacement, velocity, acceleration, force, strain, fluid pressure, fluid velocity, fluid flow rate, and temperature.
Prerequisites: E&C-ENGR 276, E&C-ENGR 277, CIV-ENGR 276, MEC-ENGR 351, MEC-ENGR 299.

MEC-ENGR 353 Heat Transfer and Fluid Mechanics Lab Credits: 2
Project-based course associated with MEC-ENGR 399 and MEC-ENGR 351. The course emphasis is on experiments related to thermodynamics, heat transfer, and fluid mechanics. Proper experimental methods, data and uncertainty analysis related to thermal and fluids measurements are discussed.
Prerequisites: MEC-ENGR 299 and MEC-ENGR 351.

MEC-ENGR 356 Mechanical Component Design Credits: 3
Introduction to mechanical engineering design and its impact on human history, principles of design with ductile and brittle materials for static and dynamic loading, classical and reliability-based factors of safety, fracture mechanics in design, application to the design of selected machine components.
Prerequisites: CIV-ENGR 276.

MEC-ENGR 360 Thermal System Design Credits: 3
Gas and vapor mixtures, cycles, availability, imperfect gases, thermodynamic relations, combustion, chemical equilibrium, power systems and design projects. Effects of design choices on the earth and living systems.
Prerequisites: MEC-ENGR 299.

MEC-ENGR 380 Manufacturing Methods Credits: 3
Introduction to manufacturing processes with emphasis on those aspects most relevant to methods, problems in force analysis, and practicum and experimentation in machine tool applications.
Prerequisites: MEC-ENGR 324.

MEC-ENGR 385 System Dynamics Credits: 3
Kinematics of mechanical systems. Introduction to the modeling and analysis of dynamic mechanical systems. Computer analysis.
Prerequisites: MEC-ENGR 272, MEC-ENGR 285.

MEC-ENGR 390 Engineering Coop/Internship Credits: 0
Students may participate in structured Engineering Coop/Internship under the supervision of employer. They must carry out significant professional responsibilities and whatever additional assignments are determined by the employer.
Prerequisites: CIV-ENGR 211, MEC-ENGR 285.

MEC-ENGR 399 Heat and Mass Transfer Credits: 3
Prerequisites: MATH 250 or MEC-ENGR 270; and MEC-ENGR 299, MEC-ENGR 351.
MEC-ENGR 399L Heat and Mass Transfer Lab Credit: 1
Project-based course associated with MEC-ENGR 399. Course emphasis is on experiments related to thermodynamics, heat transfer and fluid mechanics. Proper experimental methods, data and uncertainty analysis related to thermal and fluid measurements are discussed.

Co-requisites: MEC-ENGR 399.

MEC-ENGR 400 Problems Credits: 1-6
Special design, experimental and analytical problems in mechanical engineering.

MEC-ENGR 401AD Topics in Mechanical Engineering- Advance Dynamics and Modeling Credits: 3
Fundamental principles of advance rigid body dynamics with applications. Special mathematical techniques including Lagrangian and Hamiltonian methods.

MEC-ENGR 401CD Topics in Mechanical Engineering – Applied CFD Credits: 3
The fundamentals of computational fluid mechanics. Introduction to the governing equations and boundary conditions of viscous fluid flows, turbulence and its modelling, and how to solve a fluid flow problem using commercially available CFD software.

Prerequisites: MEC-ENGR 285.

MEC-ENGR 401ID Topics in Mechanical Engineering Credits: 3
Kinematics and dynamics of rigid bodies in space. General theory of rotating coordinate frames, Eulers angles, Eulers equations of motion, angular momentum, work-energy principles.

Prerequisites: MEC-ENGR 285.

MEC-ENGR 401MB Topics in Mechanical Engineering Credits: 3
The purpose of this course is to provide an opportunity for students to gain a hands-on, in-depth understanding of the experimental measurement and analysis techniques used to quantify the biomechanics of human motion.

Prerequisites: MEC-ENGR 411

MEC-ENGR 401MS Topics in Mechanical Engineering Credits: 3
The incorporation of material selection in the design process will be considered.

Prerequisites: MEC-ENGR 324.

MEC-ENGR 401R Topics in Mechanical Engineering Credits: 3
Introduction to and analysis of the thermodynamic cycles and equipment used in Industrial Refrigeration. Applications of Industrial Refrigeration are also discussed.

Prerequisites: MEC-ENGR 299.

MEC-ENGR 401T Topics in Mechanical Engineering Credits: 3
This course covers the application of Newton’s laws and thermodynamics to analysis of fluid flow in turbomachinery.

Prerequisites: MEC-ENGR 399.

MEC-ENGR 409 Fundamentals of Engineering Review Credit: 1
This course consists of a series of lectures given by different professors and is intended as a review class for all the subjects included in the Fundamentals of Engineering exam. Classes specifically focus on the review of equations and formulas included in the reference handbook published by NCEES.

MEC-ENGR 411 Introduction to Biomechanics Credits: 3
This course is to provide students with an introduction to the engineering principles of biomechanics.

Prerequisites: All junior-level coursework must be completed before taking this course.

MEC-ENGR 412 Biodynamics Credits: 3
Introduction to musculoskeletal biomechanics including: computational biomechanics, movement simulation, motor control and musculoskeletal tissues.

Prerequisites: MEC-ENGR 411.

MEC-ENGR 413 Experimental Biomechanics of Human Motion Credits: 3
The purpose of this course is to provide an opportunity for students to gain a hands-on, in-depth understanding of the experimental measurement and analysis techniques used to quantify the biomechanics of human motion.

Prerequisites: MEC-ENGR 411.

MEC-ENGR 414 Material Science for Advanced Applications Credits: 3
Study of the physical and mechanical metallurgy of alloy systems of interest in engineering applications.

Prerequisites: MEC-ENGR 324.
MEC-ENGR 415 Feedback Control Systems Credits: 3
Introduction to feedback control theory for linear dynamic systems. Topics include root locus analysis, frequency response analysis, and controller design.
Prerequisites: MEC-ENGR 385.

MEC-ENGR 420 Human Powered Vehicle Design Lab Credits: 3
Introduction to the science of human powered vehicles (HPV) providing the background necessary for the design of such vehicles. Students will learn and utilize engineering design practices and apply them toward the creation of an aerodynamic, highly engineered land based HPV.
Prerequisites: MATE111A Machine Shop Safety, Consent of instructor.

MEC-ENGR 424 Non-Metallic Engineering Materials Credits: 3
Structures, properties and applications of ceramics, glasses, cermets, polymers and composite materials.
Prerequisites: MEC-ENGR 324.

MEC-ENGR 425 Failure Analysis Credits: 3
Organize and perform a failure investigation. In addition, the course will cover the general procedures for a failure investigation and various failure mechanisms such as ductile fracture, brittle fracture, fatigue, wear, corrosion and elevated temperature.
Prerequisites: MEC-ENGR 324, MEC-ENGR 380.

MEC-ENGR 426 Introduction to Manufacturing Management Credits: 3
The objective of this course is to expose the student to various manufacturing management tools and techniques. Focus is on both the technical tools used in manufacturing as well as on the management tools needed to implement change in the manufacturing environment. As part of this course, students will research a successful company and present an analysis of manufacturing tools and techniques used.

MEC-ENGR 440 Heating and Air Conditioning Credits: 3
General principles of thermodynamics, heat transfer, and fluid dynamics are used to calculate building loads, size equipment and ducts, and evaluate system performance in maximizing human comfort. Consideration of indoor air quality and human health.
Prerequisites: MEC-ENGR 360, MEC-ENGR 399.

MEC-ENGR 441 Intermediate Fluid Mechanics Credits: 3
Topics in potential and viscous flow theory, and computational fluid dynamics.
Prerequisites: MEC-ENGR 351.

MEC-ENGR 444 Composite Materials Credits: 3
A survey of composite materials used in engineering, emphasizing fiber-reinforced composites as well as laminate and particulate composites.
Prerequisites: MEC-ENGR 324.

MEC-ENGR 447 Contracts and Law For Engineers Credits: 3
This course covers a broad range of substantive legal topics giving the student a grounding in the legal implications of certain situations that they may encounter during their careers. The course includes coverage of basic contract law, environmental regulations and compliance, construction law, antitrust law, intellectual property law, civil procedure, employment law, business entities (corporate law) product liability and criminal law and procedure. The objective of the course is to provide students with a fundamental understanding of the wide range of federal and state laws governing behavior in our complicated and rule of law driven society.

MEC-ENGR 449 Environmental Compliance, Auditing & Peritting Credits: 3
This course provides a high level overview of the most important statutes that have been enacted to protect the environment. The course covers regulation of hazardous waste, the Clean Air and Clean Water Acts, the Resource Conservation and Recovery Act, the All Appropriate Inquiry Rule and the law addressing sites contaminated with hazardous substances and the technology options employed to remediate those sites. In addition, the course provides coverage of environmental audits and emergency planning for extremely hazardous substances, the regulation of underground storage tanks, safe drinking water and the National Environmental Policy Act among other statutes.
Prerequisites: Senior standing.

MEC-ENGR 451 Power Plant Design Credits: 3
Preliminary component and system design. Optimum design of boilers, steam turbines, condensers and cooling towers and their integration into a system to minimize production costs and impact on the environment.
Prerequisites: MEC-ENGR 360, MEC-ENGR 399.

MEC-ENGR 452 Advanced Mechanics of Materials Credits: 3
Shear center; unsymmetric bending; curved beams; beams on elastic foundations; thick-walled cylinders. Energy methods. Torsion of noncircular sections. Theories of failure. Plate theory.
Prerequisites: CIV-ENGR 276.
MEC-ENGR 454 Power Generation Systems Credits: 3
Fundamentals of the power industry in a format suitable for all engineering disciplines. Survey of electric power systems, including fossil and nuclear steam cycles, combustion turbines, combines cycles, and renewable such as solar and wind. Introduction to major machinery components, systems, controls, and an overview of fuels, emissions, and emission control technologies.

Prerequisites: MEC-ENGR 299.

MEC-ENGR 455 Digital Control of Mechanical Systems Credits: 3
Introduction to digital control systems. Topics include Z-transforms, sampling, stability analysis, and digital controller design.

Prerequisites: MATH 345, MEC-ENGR 415.

MEC-ENGR 457 Mechatronic System Design Credits: 3
Theory and application of mechatronic systems through course instruction, laboratory activities, and student projects.

Prerequisites: MEC-ENGR 415.

MEC-ENGR 458 Modern Control Systems Credits: 3
Controller design for multiple-input/multiple-output systems; controllability and observability; stochastic control problems; regulators and tracking controllers; observers.

Prerequisites: MEC-ENGR 415.

MEC-ENGR 460 Electromechanical Conversion Credits: 3
This course describes the operation and control of electro-mechanical devices such as motors transformers to mechanical civil engineering students, including an introduction to programmable logic controllers and variable speed drives.

Prerequisites: MEC-ENGR 220, MEC-ENGR 285.

MEC-ENGR 466 Applied Optimization and Decision Modeling Credits: 3
Introduction to mathematical programming techniques and applications. Linear and integer programming, transporation models, multiple objective and goal programming.

Prerequisites: MEC-ENGR 306.

MEC-ENGR 467 Fuel Cells and Renewable Energy Systems Credits: 3
This course will provide an overview of the fundamental phenomena that govern the design and operation of fuel cells. The thermodynamics of fuel cell systems will be explored including operation of ideal fuel cells and the physical and chemical phenomena that lead to losses within the fuel cell. The course will provide the methods and techniques required to analyze the performance of low, medium, and high temperature fuel cells within an overall energy system. The fueling of fuel cells from renewable resources will also be discussed.

Prerequisites: MEC-ENGR 399.

MEC-ENGR 468 Introduction to Nuclear Engineering Credits: 3
This course provides an overview of nuclear engineering for non-nuclear engineers. The course deals primarily with nuclear reactors including topics dealing with nuclear and reactor physics, reactor kinetics and controls and radiation environment. The general reactor types are covered in some detail with other topics dealing with licensing, waste management, quality assurance, balance of plant systems (turbine island), and significant nuclear accidents are also covered. Recent design innovations including small modular reactors and fusion are discussed.

Prerequisites: MEC-ENGR 399.

MEC-ENGR 470 Experimental Design & Analysis Credits: 3
Presentation of concepts and methods of statistical analysis and the design of experiments. Concepts, techniques, interpretation, and use of results are stressed. Focus is on experimental strategy and objectives, and the application of the methods discussed, rather than the mechanics of derivation. Major sections include: a review of hypothesis testing and basic analysis of variance techniques; single factor experiments including 2k and 3k design, confounding, and Taguchi philosophy; nested and split plot designs; analysis of covariance and an introduction to response surface methods.

MEC-ENGR 484 Vibration Analysis Credits: 3
Vibration theory with application to mechanical systems.

Prerequisites: MEC-ENGR 385, MEC-ENGR 306.

MEC-ENGR 486 Applied Finite Element Analysis Credits: 3
The study of advanced simulation techniques for the solution to engineering problems. The use of Finite Element Method toward solving mechanical, structural, vibration and potential flow problems will be explored. The use of current commercial simulation tools will be used extensively.

Prerequisites: MEC-ENGR 306, MEC-ENGR 324, MEC-ENGR 385, MEC-ENGR 399.

MEC-ENGR 491 Internship Credits: 6
For International students who must register to cover off-campus employment which is approved as related to their degree by their departmental advisor and ISAO.
MEC-ENGR 492 Mechanical Design Synthesis I Credits: 3
Introduction to and application of the Engineering Design Process including: product development, needs identification, benchmarking, information gathering, concept generation, creativity methods, concept selection, professional and ethical responsibilities, and computer-aided design and rapid prototyping applications. A comprehensive design project including 3D CAD models and functioning prototypes is required.
Prerequisites: MEC-ENGR 130, MEC-ENGR 131

MEC-ENGR 493 Intermediate Dynamics Credits: 3
Theoretical discussion of kinematics and dynamics of rigid bodies in three-dimensional space. General theory of rotating coordinate frames, Euler’s angles, Euler’s equations of motion, angular momentum, work-energy principles, and Kane’s method.
Prerequisites: MEC-ENGR 285.

MEC-ENGR 495 Vehicle Dynamics Credits: 3
Analysis and prediction of the dynamic behavior of ground vehicles utilizing computer simulation. Mechanics of various suspension systems, tire-roadway interaction, vehicle aerodynamics, vehicle handling and steering characteristics.
Prerequisites: MEC-ENGR 385.

MEC-ENGR 496WI Mechanical Design Synthesis Credits: 3
Modern design theories and methodologies, with emphasis on the initial stages of the design process. Effect of design choices on the earth and living systems. Principles of embodiment design and life-cycle considerations. A comprehensive group design project is required. The course satisfies the Writing Intensive requirement.
Prerequisites: MEC-ENGR 492 or ANCH 309, RooWriter.

MEC-ENGR 499 Intermediate Heat Transfer Credits: 3
Advanced topics in conduction, convection and radiation heat transfer including transient heat transfer, phase change and heat exchangers.
Prerequisites: MEC-ENGR 399, MEC-ENGR 351.

MEC-ENGR 5500 Problems Credits: 1-6
Supervised investigation in mechanical engineering to be presented in the form of a report.

MEC-ENGR 5501 Advanced Topics In Mechanical Engineering Credits: 3
MEC-ENGR 5501AC Advanced Topics In Mechanical Engineering Credits: 3
MEC-ENGR 5501AD Advanced Topics in Mechanical Engineering Credits: 3
Advanced Topics in Mechanical Engineering
MEC-ENGR 5501CD Advanced Topics in Mechanical Engineering Credits: 3
Advanced Topics in Mechanical Engineering
MEC-ENGR 5501E Advanced Topics In Mechanical Engineering Credits: 3
MEC-ENGR 5501EC Advanced Topics In Mechanical Engineering Credits: 3
MEC-ENGR 5501EM Advanced Topics in Mechanical Engineering Credits: 3
MEC-ENGR 5501GS Advanced Topics in Mechanical Engineering Credits: 3
Advanced Topics in Mechanical Engineering
MEC-ENGR 5501H Advanced Topics In Mechanical Engineering Credits: 3
MEC-ENGR 5501HP Advanced Topics In Mechanical Engineering Credits: 3
MEC-ENGR 5501D Advanced Topics In Mechanical Engineering Credits: 3
MEC-ENGR 5501IF Advanced Topics in Mechanical Engineering Credits: 3
MEC-ENGR 5501J Advanced Topics In Mechanical Engineering Credits: 3
MEC-ENGR 5501L Advanced Topics In Mechanical Engineering Credits: 3
MEC-ENGR 5501M Advanced Topics In Mechanical Engineering Credits: 3
MEC-ENGR 5501MB Advanced Topics In Mechanical Engineering Credits: 3
MEC-ENGR 5501MS Advanced Topics in Mechanical Engineering Credits: 3
MEC-ENGR 5501N Advanced Topics In Mechanical Engineering Credits: 3
MEC-ENGR 5501OE Advanced Topics In Mechanical Engineering Credits: 3
MEC-ENGR 5501P Advanced Topics In Mechanical Engineering Credits: 3
MEC-ENGR 5501PL Advanced Topics In Mechanical Engineering Credits: 3
MEC-ENGR 5501PL1 Advanced Topics In Mechanical Engineering Credits: 3
MEC-ENGR 5501PL2 Advanced Topics In Mechanical Engineering Credits: 3
MEC-ENGR 5501R Advanced Topics In Mechanical Engineering Credits: 3
MEC-ENGR 5501RE Advanced Topics in Mechanical Engineering Credits: 3
MEC-ENGR 5501SB Advanced Topics in Mechanical Engineering Credits: 3
MEC-ENGR 5501SM Advanced Topics in Mechanical Engineering Credits: 2
This course is for high school science teachers who have attended the ASM International Second Year Teachers Camp and have demonstrated the use of camp material in the classroom.
MEC-ENGR 5501TC Advanced Topics in Mechanical Engineering Credits: 2
This course is for high school science teachers who have attended the ASM International Teachers camp and have demonstrated the use of camp material in the classroom.
MEC-ENGR 5501TS Advanced Topics in Mechanical Engineering Credits: 1-3
MEC-ENGR 5501VA Advanced Topics in Mechanical Engineering Credits: 3
MEC-ENGR 5501Z Advanced Topics in Mechanical Engineering Credits: 3
MEC-ENGR 5505 Imaging Techniques in Materials Science Credits: 3
Introduction to imaging techniques, including x-rays, neutron beams, electron beams and acoustic energy, to study material properties and structure. 
Prerequisites: MEC-ENGR 324.
MEC-ENGR 5511 Introduction to Biomechanics Credits: 3
This course is to provide students with an introduction to the engineering principles of biomechanics.
MEC-ENGR 5512 Biodynamics Credits: 3
Introduction to musculoskeletal biomechanics including: computational biomechanics, movement simulation, motor control and musculoskeletal tissues.
Prerequisites: MEC-ENGR 5511.
MEC-ENGR 5513 Experimental Biomechanics of Human Motion Credits: 3
The purpose of this course is to provide an opportunity for students to gain a hands-on, in-depth understanding of the experimental measurement and analysis techniques used to quantify the biomechanics of human motion.
Prerequisites: MEC-ENGR 5511.
MEC-ENGR 5514 Material Science for Advanced Application Credits: 3
Study of the physical and mechanical metallurgy of alloy systems of interest in engineering applications.
Prerequisites: MEC-ENGR 324.
MEC-ENGR 5525 Failure Analysis Credits: 3
Organize and perform a failure investigation. In addition, the course will cover the general procedures for a failure investigation and various failure mechanisms such as ductile fracture, brittle fracture, fatigue, wear, corrosion and elevated temperature.
Prerequisites: MEC-ENGR 324, MEC-ENGR 380.

Cross Listings: MEC-ENGR 425.
MEC-ENGR 5526 Introduction to Manufacturing Management Credits: 3
The objective of this course is to expose the student to various manufacturing management tools and techniques. Focus is on both the technical tools used in manufacturing as well as on the management tools needed to implement change in the manufacturing environment. As part of this course, students will research a successful company and present an analysis of manufacturing tools and techniques used.

Cross Listings: MEC-ENGR 426.

MEC-ENGR 5533 Statistical Thermodynamics Credits: 3
Statistical methods of evaluating thermodynamic properties. Elements of quantum mechanics, statistical mechanics and kinetic theory applied to topics of engineering thermodynamics.

Prerequisites: MEC-ENGR 360, MEC-ENGR 399.

MEC-ENGR 5542 Introduction to Computational Fluid Dynamics and Heat Transfer Credits: 3
Introduction to the principles and development of the finite-difference approximations to the governing differential equations of viscous and inviscid fluid flow, as well as heat transfer. Introduction to discretization methods and the calculation of flow fields, convection, diffusion and conduction.

Prerequisites: MEC-ENGR 399, MEC-ENGR 441.

MEC-ENGR 5543 Industrial Refrigeration Credits: 3
Introduction to and analysis of the thermodynamic cycles and equipment used in Industrial Refrigeration. Applications of Industrial Refrigeration are also discussed.

Prerequisites: Mec-Engr 299.

MEC-ENGR 5547 Contracts and Law for Engineers Credits: 3
This course covers a broad range of substantive legal topics giving the student a grounding in the legal implications of certain situations that they may encounter during their careers. The course includes coverage of basic contract law, environmental regulations and compliance, construction law, antitrust law, intellectual property law, civil procedure, employment law, business entities (corporate law) product liability and criminal law and procedure. The objective of the course is to provide students with a fundamental understanding of the wide range of federal and state laws governing behavior in our complicated and rule of law driven society.

Cross Listings: MEC-ENGR 447

MEC-ENGR 5549 Environmental Compliance, Auditing & Permitting Credits: 3
This course provides a high level overview of the most important statutes that have been enacted to protect the environment. The course covers regulation of hazardous waste, the Clean Air and Clean Water Acts, the Resource Conservation and Recovery Act, the All Appropriate Inquiry Rule and the law addressing sites contaminated with hazardous substances and the technology options employed to remediate those sites. In addition, the course provides coverage of environmental audits and emergency planning for extremely hazardous substances, the regulation of underground storage tanks, safe drinking water and the National Environmental Policy Act among other statutes.

Prerequisites: ANCHOR 201/CIV-ENGR 211, MEC-ENGR 285.

Cross Listings: MEC-ENGR 449.

MEC-ENGR 5554 Power Generation Systems Credits: 3
Fundamentals of the power industry in a format suitable for all engineering disciplines. Survey of electric power systems, including fossil and nuclear steam cycles, combustion turbines, combines cycles, and renewable such as solar and wind. Introduction to major machinery components, systems, controls, and an overview of fuels, emissions, and emission control technologies.

Prerequisites: MEC-ENGR 299.

Cross Listings: MEC-ENGR 454.

MEC-ENGR 5557 Mechatronics System Design Credits: 3
Theory and application of mechatronic systems through course instruction, laboratory activities, and student projects.

Prerequisites: MEC-ENGR 352 and MEC-ENGR 415.

Cross Listings: MEC-ENGR 457.

MEC-ENGR 5558 Intermediate Dynamics Credits: 3
Development of kinematics and dynamics of rigid bodies in three-dimensional space including: general theory of rotating coordinate frames, Eulers angles, Eulers equations of motion, angular momentum, work-energy principles, and Kane's method for creation and simulation of dynamic models.

Prerequisites: MEC-ENGR 285.

MEC-ENGR 5560 Electromechanical Conversion Credits: 3
This course describes the operation and control of electro-mechanical devices such as motors transformers to mechanical civil engineering students, including an introduction to programmable logic controllers and variable speed drives.

Prerequisites: MEC-ENGR 220 (or equivalent).

Cross Listings: MEC-ENGR 460.
MEC-ENGR 5563 Engineer in Society - Construction Law Credits: 3
This course introduces professional, ethical, and legal concepts of the professional practice of engineering, and the role of the consulting engineer, specifically in the A/E/C industry during the design, procurement, and construction processes. A conceptual framework is developed for understanding the industry standard agreements (AIA, EJCDC, ConCensus) and the various participants roles and duties in project execution. The engineer’s “professional standard of care” is examined and revisited throughout the semester, specifically what it means to be a “Professional Engineer”. Emphasis is placed on project and contract management and the applicable law. Skills are developed in finding online resources of law, legal, and practice advice relevant to the practice of engineering and the construction industry.

Prerequisites: MEC-ENGR 399.

Cross Listings: MEC-ENGR 467.

MEC-ENGR 5568 Introduction to Nuclear Engineering Credits: 3
This course provides an overview of nuclear engineering for non-nuclear engineers. The course deals primarily with nuclear reactors including topics dealing with nuclear and reactor physics, reactor kinetics and controls and radiation environment. The general reactor types are covered in some detail with other topics dealing with licensing, waste management, quality assurance, balance of plant systems (turbine island), and significant nuclear accidents are also covered. Recent design innovations including small modular reactors and fusion are discussed.

Prerequisites: MEC-ENGR 399.

Cross Listings: MEC-ENGR 468.

MEC-ENGR 5570 Experimental Design & Analysis Credits: 3
Presentation of concepts and methods of statistical analysis and the design of experiments. Concepts, techniques, interpretation, and use of results are stressed. Focus is on experimental strategy and objectives, and the application of the methods discussed, rather than the mechanics of derivation. Major sections include: a review of hypothesis testing and basic analysis of variance techniques; single factor experiments including 2k and 3k design, confounding, and Taguchi philosophy; nested and split plot designs; analysis of covariance and an introduction to response surface methods.

MEC-ENGR 5572 Advanced Statistics Credits: 3
The objective of this course is to review the concepts and methods of undergraduate first course in statistical analysis and extend the student’s understanding to cover topics typically covered in a second course in applied engineering statistics. Concepts, techniques, interpretation, and use of results are stressed. Focus is on the application of the methods discussed, rather than the mechanics of derivation.

Prerequisites: CIV-ENGR 319 (or equivalent).

MEC-ENGR 5574 Linear Programming for Engineering Optimization Credits: 3
This course will cover techniques and applications of engineering optimization using linear programming techniques. The main topics will be the simplex algorithm, sensitivity analysis, duality, network models, and integer programming. Main applications will include transportation, shipments, and utility planning. Stochastic models, game theory, non-linear programming, and heuristic optimization techniques will be briefly mentioned, but not explored in detail. At the conclusion of the course the student should be able to formulate and solve optimization problems in several areas of engineering.

Prerequisites: MEC-ENGR 306.

MEC-ENGR 5586 Applied Finite Element Analysis Credits: 3
The study of advanced simulation techniques for the solution to engineering problems. The use of Finite Element Method toward solving mechanical, structural, vibration and potential flow problems will be explored. The use of current commercial simulation tools will be used extensively.

Prerequisites: CIV-ENGR 275, MATH 5517, MEC-ENGR 130.

MEC-ENGR 5595 Microscale Heat Transfer Credits: 3
Review of existing models. Concept of thermal lagging and the second-law admissibility. Applications to low temperatures, thermal processing of thin-film devices; amorphous materials; advanced composites.

Prerequisites: MEC-ENGR 399.
MEC-ENGR 5599 Research Credits: 1-99
Independent investigation in field of mechanical engineering to be presented as a thesis.

MEC-ENGR 5601 Doctoral Topics In Mechanical Engineering Credits: 3

MEC-ENGR 5601AC Doctoral Topics In Mechanical Engineering Credits: 3

MEC-ENGR 5601C Doctoral Topics In Mechanical Engineering Credits: 3

MEC-ENGR 5601F Doctoral Topics in Mechanical Engineering Credits: 3

MEC-ENGR 5601G Doctoral Topics In Mechanical Engineering Credits: 3

MEC-ENGR 5601H Doctoral Topics In Mechanical Engineering Credits: 3

MEC-ENGR 5601J Doctoral Topics in Mechanical Engineering Credits: 3

MEC-ENGR 5601R Doctoral Topics In Mechanical Engineering Credits: 3

MEC-ENGR 5601SA Doctoral Topics In Mechanical Engineering Credits: 3

MEC-ENGR 5603 Directed Readings in Mechanical Engineering Credits: 1-3
Faculty supervised readings course.

Prerequisites: Graduate standing.

MEC-ENGR 5610 Seminar Credit: 1
Review recent investigations, projects of major importance in mechanical engineering.

MEC-ENGR 5616 Theory of Plasticity Credits: 3
Plastic yield conditions and stress-strain relations. Behavior of elastic-perfectly plastic members. Plain strain in plastic members.
Prerequisites: MEC-ENGR 5621, MEC-ENGR 5622.

MEC-ENGR 5618 Multibody System Dynamics Credits: 3
Fundamental principles of advanced rigid body dynamics with applications. Special mathematical techniques including Lagrangian and Hamiltonian methods.
Prerequisites: MEC-ENGR 285, MEC-ENGR 401ID

MEC-ENGR 5621 Continuum Mechanics Credits: 3
Introductory course in the mechanics of continuous media. Basic concepts of stress, strain, constitutive relationships; conservation laws are treated using Cartesian tensor notation. Examples from both solid and fluid mechanics investigated.
Prerequisites: CIV-ENGR 276, MATH 345, MEC-ENGR 351.

MEC-ENGR 5622 Theory of Elasticity Credits: 3
Prerequisites: MEC-ENGR 5621.

Cross Listings: CIV-ENGR 5622.

MEC-ENGR 5623 Theory Of Plates And Shells Credits: 3
Bending of plates with various loading and boundary conditions. Deformations, stresses in thin shells.
Prerequisites: MEC-ENGR 5621.

Cross Listings: CIV-ENGR 5623.

MEC-ENGR 5624 Theory of Elastic Stability Credits: 3
Buckling of columns, beams, rings, curved bars, thin plates, shells.
Prerequisites: MEC-ENGR 5621.

Cross Listings: CIV-ENGR 5624.

MEC-ENGR 5627 Dynamics of Machinery Credits: 3
Dynamic balancing or rotating and reciprocating components of turbo-machinery and internal combustion engines. Gas torque analysis, vibration stress analysis and equivalent systems. Numerical and graphical techniques.
Prerequisites: MEC-ENGR 484.

MEC-ENGR 5630 Boundary Layer Theory Credits: 3
Fluid motion at high Reynolds Number. Derivation of Navier-Stokes equations and boundary layer equations. Methods of solution. Transition to turbulent flow. Completely developed turbulent flow.
Prerequisites: MEC-ENGR 441.
MEC-ENGR 5636 Heat Transfer-Convection Credits: 3
Concepts including fluid dynamics, conservation laws, thermal boundary layer theory, forced convection in laminar and turbulent flows, and free convection will be developed and applied.
Prerequisites: MEC-ENGR 399

MEC-ENGR 5637 Heat Transfer-Radiation Credits: 3
Prerequisites: MEC-ENGR 399.

MEC-ENGR 5639 Introduction to Two Phase Flow Credits: 3
The fundamental principles of two-phase flow with applications to a variety of homogeneous mixture as well as separated liquid-liquid, gas-solid, liquid-solid, and gas-liquid flow problems, including steady or transient, laminar or turbulent conditions.
Prerequisites: MEC-ENGR 441.

MEC-ENGR 5643 Industrial Refrigeration Credits: 3
Introduction to and analysis of the thermodynamic cycles and equipment used in Industrial Refrigeration. Applications of Industrial Refrigeration are also discussed.

MEC-ENGR 5660 Combustion Credits: 3
Study of advanced topics in flames and combustion. Detonation and deflagrations, supersonic combustion, air pollution.
Prerequisites: MEC-ENGR 441.

MEC-ENGR 5679 Dynamics of Structures Credits: 3
Study of the dynamic behavior of structures. Analysis of equivalent lumped parameter systems for the design of structures in a dynamic environment.
Prerequisites: CIV-ENGR 276 (or CIV-ENGR 421), MEC-ENGR 484 (or MATH 345, MEC-ENGR 285).

MEC-ENGR 5685 Advanced Vibration Analysis Credits: 3
Advanced topics in vibration theory and its application to Mechanical systems. Topics include vibration analysis of multi-degree of freedom, distributed and nonlinear systems, random vibration analysis, and vibration control.
Prerequisites: MEC-ENGR 484.

MEC-ENGR 5699 Research And Dissertation Credits: 1-9
Doctoral dissertation research.