**SCHOOL OF COMPUTING AND ENGINEERING**

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**Mailing Address**  
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**Dean:**  
Kevin Z. Truman

**Associate Dean of Faculty & Research**  
Masud Chowdhury

**Assistant Dean of Academic Affairs**  
Katherine H. Bloemker

**Assistant Dean of Student Affairs**  
Marjory Eisenman

**Department of Civil and Mechanical Engineering:**  
**Chair:**  
John T. Kevern  
352 Flarsheim Hall

See CME Catalog ([http://catalog.umkc.edu/colleges-schools/computing-engineering-school-of/civil-engineering-mechanical-engineering-department/](http://catalog.umkc.edu/colleges-schools/computing-engineering-school-of/civil-engineering-mechanical-engineering-department/))

**Department of Computer Science Electrical Engineering:**  
**Interim Chair:**  
Masud Chowdhury  
546 Flarsheim Hall


**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 work force and research needed for economic development.

**Departments and Degree Programs**

The School of Computing and Engineering has two departments:

- Civil and Mechanical Engineering ([http://sce.umkc.edu/cme/](http://sce.umkc.edu/cme/))
- Computer Science Electrical Engineering ([http://sce.umkc.edu/about/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](http://www.abet.org), M.S. in Civil Engineering,
and M.S. in Mechanical Engineering. The Computer Science Electrical Engineering Department offers B.A./B.S. in Computer Science, B.S. in Electrical
& Computer Engineering, Bachelor of Information Technology (B.I.T), M.S. in Computer Science, and M.S. in Electrical Engineering. The B.S. in
Computer Science and the Bachelor of Information Technology degrees are accredited by the Computing Accreditation Commission of ABET,
www.abet.org.

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 Aid & Scholarships

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. Current SCE scholarship recipients must re-
apply each year by March 1 to be considered for the next academic year.

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.

Admissions

High school students planning to apply to the School of Computing & Engineering are strongly encouraged to take a college preparatory program that
emphasizes mathematics, science and communication skills.

First-time college student applicants to the undergraduate program in civil engineering will be automatically admitted if they obtain:

1. An ACT mathematics score of at least 25 and
2. An ACT composite score of at least 24 and
3. A 3.0 Core High School GPA.

First-time college student applicants who do not meet the above criteria but do meet UMKC general admission requirements will have their
applications reviewed by a faculty committee for admission. Applicants who are not admitted to SCE but do meet UMKC general admission
requirements may be admitted to University College.

Students without the prerequisite preparation must take the needed coursework before enrolling in courses required for the bachelor’s degree.
Students seeking re-admission must have been in good academic standing when last enrolled. Otherwise, re-admission requires a formal review by the
undergraduate program committee.

Transfer applicants must have at least 24 credits of transferable college credit, an overall 2.0 GPA on a 4.0 scale in all coursework, which includes
repeated coursework, attempted at previous institutions. Transfer applicants without a 2.0 or higher college GPA must submit a petition for admission.

Student Life

Students enjoy many group activities outside the classroom. They participate in regional and national competitions, design and erect bridges, build
and race buggies and robots, compete in hackathons, and participate in Engineers’ Week activities.

The School of Computing and Engineering has a number of societies open to all students. These include the SCE Student Council, and the student
chapters of the American Society of Civil Engineers (ASCE), the National Society of Black Engineers (NSBE), the Society of Women Engineers (SWE)
the Institute of Electrical & Electronics Engineering (IEEE), Association of Computing Machinery (ACM), and Engineers Without Border (EWB). In these
organizations, students have an opportunity to develop their career through association with other students, the faculty, and active members of the
profession.
Several national honorary societies have also been established to recognize academic excellence. Students are invited to join based on their academic performance.

A list of active organizations and contact information is at https://sce.umkc.edu/resources/student-life/.

**BS/MS Program**

The School of Computing and Engineering established the BS/MS program to offer students an opportunity to meet the full requirements of the existing BS and MS degree programs in a shorter time period than the separate degree programs by completing a B.S. degree within four years and then completing an M.S. degree in the fifth year.

- Must be continuously enrolled from BS to MS programs (must enter graduate program the semester following completion of BS degree requirements, summer excepted)
- Students admitted to the program will receive the SCE BS/MS Scholarship which will cover the difference between Graduate and Undergraduate tuition rates
- Students are required to maintain full-time graduate enrollment (minimum 9 hours/semester) and complete the masters degree within the year following the completion of their bachelor’s degree to remain enrolled in the program and receive the BS/MS Scholarship.

**Admission Requirements for BS/MS Program:**

Students must meet the following requirements to be eligible:

- No GRE is required. Students must have a cumulative 3.0 GPA at UMKC to be admitted.
- Students should indicate their interest and apply to the program no later than the end of their junior year
- Students must complete 30 hours at SCE prior to admission to the BS/MS program

Interested students should speak with their academic advisor about the application process.

**Dual Degree Programs**

The School of Computing and Engineering collaborates with other institutions in our dual-degree program which leads to undergraduate degrees in both a liberal arts and sciences major and a professional engineering, computer science or information technology degree. Students enter UMKC SCE following three (or four) years at their first institution. Students who follow the guidelines and meet the admission requirements will earn a degree from their first institution and a degree from UMKC following approximately two years of study at SCE.

Students who complete the dual degree program experience the benefits of a liberal arts and sciences education, allowing them to become better communicators, develop strong study skills and explore additional academic interests, while also finishing a professional degree program.

Students who are interested in the dual degree program should consult the SCE website (http://sce.umkc.edu) and discuss the curriculum requirements with their home institution to be sure they are taking the correct coursework. Every program is different, depending on course offerings and general education requirements, so it is important for students interested in these programs to plan ahead.

**Undergraduate Advising**

Roo Advising (http://catalog.umkc.edu/roo-advising/)

rooadvising@umkc.edu

816-235-1148

Academic advising for undergraduate students is delivered through Roo Advising. Academic Advising is an integral part of student’s university experience and has a significant impact on student success. The goals of Roo Advising are to provide students an exceptional advising experience that is equitable, holistic, personal, and timely. Advisors will assist students with the following:

- Understand degree requirements and have a early plan to graduation
- Navigate UMKC processes, systems, and services
- Explore, clarify and confirm fit with their major and career plans
- Develop clear and personalized academic objectives for short and long-term goals
- Enhance self-efficacy and sense of agency

Our professional academic advisors will assist students in all aspects of their undergraduate educational career.

- Assist students in choosing majors and developing academic plans
- Inform students about general education requirements
- Advise students on class selection and registration
School of Computing and Engineering

- Offer advice on educational and career goals
- Assist students to connect with support services on campus
- Regularly review academic progress and progression toward degree completion
- Connect students with faculty mentors and UMKC Career Services
- Review academic policies and procedures
- Help students with other related issues or problems of an academic nature

**Academic Advising**

To facilitate progress toward the student’s degree, and to ensure that courses selected support completion of degree requirements, students are required to participate in advising each semester before registering for classes. Academic advising is required for all undergraduate students and is enforced using an advising hold in Pathway. In general, students should schedule an appointment to meet with their assigned academic advisor to discuss their enrollment plan and request their advising hold be released. Once students have a fully approved academic plan, there may be options to have holds released without a requirement for an appointment with certain programs.

Students enrolled in double majors or dual degree programs may be advised by two or more advisors with expertise in the specific programs. The advisor for student’s primary degree program will have the major advising responsibility.

Students have many options to meet with their assigned academic advisor. Students are encouraged to schedule an appointment with their assigned advisor to ensure appropriate time is set aside to address student’s issues and concerns.

**Schedule an appointment**

Students can schedule an appointment to meet with their assigned academic advisor on their own through UMKC Connect (https://umkc.starfishsolutions.com/starfish-ops/support/login.html). If assistance is required, students can call Roo Advising at 816-235-1148 or send an email to rooadvising@umkc.edu.

**Walk-in Advising**

Walk-In Advising will be available the week prior to and the first week of each term. In addition, walk-in advising is available during regular terms.

- Monday and Tuesday 11am-12:00pm
- Wednesday and Thursday 1:00pm-2:00pm

**Advising Office Locations**

Roo Advising is delivered across UMKC

- Arts & Cultural Studies-Scofield Hall, Room 9
- Business & Management-Scofield Hall, Room 9
- Human Behavior, Education & Justice-Scofield Hall, Room 9 and School of Education, Suite 129 (for education majors only)
- Natural & Health Sciences-Flarsheim Hall, Suite 510 (including Health Sciences-non nursing tracks and public health)and Health Sciences Building (Health Sciences Campus, 2411 Holmes, Kansas City, MO) Suite 1410 (for Health Sciences nursing tracks and Nursing program only)
- Numbers, Engineering, Technology, & the Cosmos-Flarsheim Hall, Suite 336

**Faculty Mentors**

Faculty in student’s declared degree programs are a significant and valuable resource for students. As experts in their respective fields they can assist students with their exploration of major and career options. Faculty can assist students to consider elective options tailored to their specific interests and assist students to make connections with professionals in Kansas City, Missouri, the United States, or across the globe. In addition, faculty can help students to make connections with colleagues in graduate or professional schools that may be of interest to students.

Students are responsible for becoming familiar with all academic regulations of the campus as outlined in the catalog and in other University documents.

**Faculty**

**Department of Civil and Mechanical Engineering**

**Mujahid Abdullah**; assistant professor; B.S., M.S., Ph.D. (University of Florida).

**Walter A. Accurso**; instructor; B.S. (University of Kansas); M.B.A. (Keller Graduate School of Management).

**C. Mauli Agrawal**; chancellor, UMKC; professor; B.Tech. (Indian Institute of Technology Kanpur, India); M.S. (Clemson University); Ph.D. (Duke University).
Bryan R. Becker; professor emeritus; B.S. (University of Missouri-Rolla); M.S. (University of Missouri-Columbia); Ph.D. (University of Tennessee-Knoxville); P.E.

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

Darran Cairns; associate teaching professor; B.SC., Ph.D. (University of Birmingham).

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

Mun Y. Cho; president, UM System; professor; B.S. (University of Illinois-Urbana Champaign); M.A., Ph.D. (Princeton University).

Travis Fields; associate professor; B.S., M.S., Ph.D. (University of Nevada, Reno).

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

Ceki Halmen; associate professor; B.S. (Bogazici University, Istanbul, Turkey); M.S., Ph.D. (Texas A&M University).

Amirfarhang Mehdizadeh; assistant professor; B.S. (University of Tehran, Iran); M.S., Dr.Ing. (Darmstadt University of Technology, Germany).

Zahra Niroobakhsh; assistant professor; B.S. (University of Tehran, Iran); M.S. (Technical University of Darmstadt, Germany); Ph.D. (The Pennsylvania State University).

Deborah J. O'Bannon; professor emeritus; B.S. (Massachusetts Institute of Technology); M.Eng. (Manhattan College); Ph.D. (University of Iowa); P.E.

Jerry E. Richardson; associate professor emeritus; 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).

Sarvenaz Sobhansarbandi; assistant professor; B.S. (University of Kashan, Iran); M.S. (Eastern Mediterranean University, Cyprus); Ph.D. (University of Texas at Dallas)

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

Antonis Stylianou; associate professor; B.S., M.S., Ph.D. (University of Kansas).

Kevin Z. Truman; dean, School of Computing & Engineering, and professor; 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; associate professor; B.S., M.S. (University of Missouri-Columbia); Ph.D. (University of Kansas).

Kendall Bingham; instructor; B.S., M.S. (University of Missouri-Kansas City).

Deb Chatterjee; 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; professor emeritus; B.S. (University of Punjab, Pakistan); M.S. (B.Z. University, Pakistan); M.S., Ph.D. (Wayne State University).

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

Masud H. Chowdhury; interim chair, department of computer science and electrical engineering, and professor; B.S. (Bangladesh U. of Engineering & Technology, Dhaka 1000, Bangladesh); Ph.D. (Northwestern University).

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

Wajeb Gharibi; associate teaching professor; Ph.D (Belarus Academy of Sciences).
Civil Engineering Courses
CIV-ENGR 111 First Year Cornerstone Credit: 1
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 113 Engineering Measurements 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 190 Special Topics Credits: 1-3
Selected introductory topics in the area of computing. May be repeated for credit when topic varies.

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: SCE Student.

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: MATH 268 or MATH 220.

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. Machine Shop Safety is required prior to taking this class.
Prerequisites: CIV-ENGR 276, CHEM 211, CHEM 211L.

CIV-ENGR 342 Introduction to Environmental Engineering 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 or MEC-ENGR 351; and 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: CIV-ENGR 275.

Co-requisites: MATH 345 or MEC-ENGR 272.

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 or MEC-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 theses concrete systems will be studied. Machine Shop Safety is required prior to taking this course.
Prerequisites: CHEM 211, CHEM 211L, CIV-ENGR 276.
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: Departmental consent.

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

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 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 406 Construction Project Risk Management Credits: 3
Risk management skill sets are necessary tools for the successful project manager. Project Management Institute’s (PMI) 6 steps of project risk management constitute the basis of the content, which includes an expanded knowledge of risk identification, qualitative and quantitative risk analysis, risk control, contract risks, and risk transfer options. Business and project risks such as client selection, project planning, and project execution, will be considered as well as legacy risks that remain with the business and participants beyond the project completion. Different risk management strategies will be discussed, including risk avoidance, risk mitigation, and risk transfer.
Prerequisites: Senior Standing.

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 467 and CIV-ENGR 497.

Co-requisites: CIV-ENGR 422WI and CIV-ENGR 432.

CIV-ENGR 412 Civil Engineering Systems Design II Credits: 3
Continuation of CIV-ENGR 411.
Prerequisites: CIV-ENGR 411 and departmental consent.
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 417 Advanced Structural Analysis Credits: 3
The course is designed as a continued study of structural analysis methods with emphases on indeterminate structures (trusses, beam/columns, and frames), advanced analysis methods, and introduction to nonlinear structural effects including geometric nonlinearity and inelasticity. Advanced structural analysis methods including force, displacement, matrix, energy, and limit analysis methods will be introduced and practiced. Both computer based and hands-on analysis will be involved.
Prerequisites: CIV-ENGR 321

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.

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 357.

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.
**Prerequisites:** Senior standing.

### 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.
**Prerequisites:** Senior standing.

### 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 357.

### 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 357.

### 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 457 River Stability and Scour 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.
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), and MEC-ENGR 285.

CIV-ENGR 481 Introduction to Transportation 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.

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: 0-6
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.
Prerequisites: Departmental consent.

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; and CIV-ENGR 351 or MEC-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 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 5506 Construction Project Risk Management Credits: 3
Risk management skill sets are necessary tools for the successful project manager. Project Management Institute’s (PMI) 6 steps of project risk management constitute the basis of the content, which includes an expanded knowledge of risk identification, qualitative and quantitative risk analysis, risk control, contract risks, and risk transfer options. Business and project risks such as client selection, project planning, and project execution, will be considered as well as legacy risks that remain with the business and participants beyond the project completion. Different risk management strategies will be discussed, including risk avoidance, risk mitigation, and risk transfer.

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.

CIV-ENGR 5516 Advanced Engineering Mathematics Credits: 3
The class is a review of and introduction to advanced mathematical theories and methods for graduate students in Civil and Mechanical Engineering. The basic topics include 2nd-order ODE/PDEs, advanced linear algebra, continuous and discrete Fourier transform, advanced probability and statistics methods, and commonly numerical methods (e.g. linear and generalized linear regression, iterative methods, and maximum likelihood estimation. Successful completion of Calculus III and working knowledge of a mathematical software package (Matlab preferred) is recommended.

CIV-ENGR 5517 Advanced Structural Analysis Credits: 3
The course is designed as a continued study of structural analysis methods with emphases on indeterminate structures (trusses, beam/columns, and frames), advanced analysis methods, and introduction to nonlinear structural effects including geometric nonlinearity and inelasticity. Advanced structural analysis methods including force, displacement, matrix, energy, and limit analysis methods will be introduced and practiced. Both computer based and hands on analysis will be involved.
**Prerequisites:** Undergraduate coursework in structural analysis strongly recommended.

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.

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, prestressed design.
**Prerequisites:** CIV-ENGR 422WI.
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.

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

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.

CIV-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.

CIV-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.

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.
Prerequisites:

- CHEM 211

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.

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.

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.

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 or CIV-ENGR 5567.

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 or CIV-ENGR 5567.

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.

Cross Listings: CIV-ENGR 473.

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 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.

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 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

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.

CIV-ENGR 5624 Theory of Elastic Stability Credits: 3
Buckling of columns, beams, rings, curved bars, thin plates, shells.
Prerequisites: CIV-ENGR 5622.
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 5649.

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  
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 5675 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 5679 Dynamics of Structures Credits: 3  
Study of the dynamic behavior of structures. Analysis of equivalent lumoed 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 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 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 (or higher) or ALEKS score of 51 (or higher); or ACT Math sub-score of 28 or higher; or SAT Math sub-score of 660 or higher.

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 MATH 120 (or higher) or ALEKS score of 51 (or higher); ACT Math sub-score of 28 or higher; or SAT Math sub-score of 660 or higher.

Co-requisites: COMP-SCI 101L.

COMP-SCI 101L Problem Solving & Programming I Lab Credit: 1
Programming exercises and demonstrations to reinforce concepts learned in COMP-SCI 101 and provide additional practice in Python programming.

Prerequisites: MATH 110 or MATH 120 (or higher); ACT Math sub-score of 28 or higher; or SAT Math sub-score of 660 or higher.


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 MATH 120 (or higher) or ALEKS score of 51 (or higher); or ACT Math sub-score of 28 or higher; or SAT Math sub-score of 660 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.

Co-requisites: COMP-SCI 191 and 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.

Co-requisites: COMP-SCI 191 and 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 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: Departmental consent.
COMP-SCI 320 Data Communications and Networking Credits: 3
This course examines the fundamental aspects of data communications and computer networks. Students will learn the concepts of layered models, communication protocols, digital transmission and encoding techniques, multiplexing techniques, error detection and correction concepts, the data link layer and its associated protocols, LAN architectures, switching techniques, major Internet protocols and standards, internetworking, addressing, and routing concepts. By the end of the course, students will be familiar with all networking concepts and technologies and will be able to size and implement different types of networking architectures. Part of the course will be devoted to the use of opensource software tools, such as Cisco Packet Tracer and Wireshark, to experiment with network architectures and analyze network traffic. Prerequisites: COMP-SCI 291.

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

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, or STAT 115, or MOTRMATH 110).

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 complexity theory and NP-complete theory. Prerequisites: COMP-SCI 291 and COMP-SCI 303.

COMP-SCI 420 Advanced Networking and Applications Credits: 3
This course provides advanced knowledge in computer networking and applications. More specifically, the students will learn new networking concepts, such as software-defined networking (SDN), next-generation networking protocols, such as IPv6, how streaming of multimedia flows and group communications are performed in the Internet, how networks are managed through remote network management platforms, and how to secure networking architectures. Prerequisites: COMP-SCI 320.

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 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.

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, security, protection, 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, concurrency/parallelism, and abstraction. It also covers programming language specification, grammar, lexical analysis, exception handling, and runtime considerations. Prerequisites: COMP-SCI 303.
COMP-SCI 449 Foundations of Software Engineering Credits: 3
The course introduces concepts of software engineering (e.g. definitions, context) and the software development process (i.e. life cycle). Students will get a solid foundation in agile methodology, software requirements, exceptions and assertions, verification and validation, software models and modeling, and user interface design. Various software architectures will be discussed.
Prerequisites: COMP-SCI 303.

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 system integration and architecture, 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, 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 user 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 303.

COMP-SCI 458 Software Testing and Verification Credits: 3
Introduction to principles and techniques of software testing and verification for quality assurance in software development processes.
Prerequisites: COMP-SCI 303.

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 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 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 479 Introduction to Computer Vision Credits: 3
Image is an essential form of information representation and communication in modern society. This course focuses on topics of computer vision, teaching computers how to understand images. Introductory topics include image formation, color and texture features, homograph, key points detection, aggregation, subspace methods in image modeling, and deep learning based image segmentation and classification, with applications in photography, media and entertainment, education, defense and medicine. The course is project based and emphasis hands on experiences for students to solve real world problems.
Prerequisites: E&C-ENGR 484.

COMP-SCI 490 Special Topics Credits: 3
Selected topics in specific areas of computer science. May be repeated for credit when the topic varies.
Prerequisites: Junior standing.
COMP-SCI 490CR Special Topics Credits: 1-3
Special topics in Computer Science.

COMP-SCI 490R Special Topics Credits: 1-3
Selected topics in specific areas of computer science. May be repeated for credit when the topic varies.

COMP-SCI 491 Internship Credits: 0-6
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/IT 491 Internships are available in the office of CSEE Division and on the web. **Prerequisites:** Junior standing, Departmental consent.

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. **Prerequisites:** Departmental consent.

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. **Prerequisites:** Departmental consent.

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. **Prerequisites:** Departmental consent.

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 5104 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 5525 Cloud Computing Credits: 3
Cloud computing systems operate in 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 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 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 and COMP-SCI 470.

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: 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: 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 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.

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.

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.

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 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. Recommended preparation: MATH 300; Familiarity with MATLAB.
Prerequisites: COMP-SCI 394R.
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 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.
**Recommended preparation:** COMP-SCI 5565.
**Prerequisites:** COMP-SCI 303, COMP-SCI 394R.

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 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 470.

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.

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 5582 Computer Vision Credits: 3
The image is an essential form of information representation and communication in modern society. This course focuses on topics of computer vision, teaching computer how to understand images. Topics include image formation, color and texture features, key points detection, aggregation, subspace methods in image modeling, and deep learning image classification, with many applications in photography, media and entertainment, education, defense and medicine.

COMP-SCI 5590 Special Topics Credits: 1-6
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 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 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 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 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, and 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 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 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 and C languages. Introduction to algorithms and data structures.

**Prerequisites:** MATH 110 or MATH 120 (or higher) or ALEKS score of 51 (or higher); or ACT Math sub-score of 28 or higher; or SAT Math sub-score of 660 or higher.

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 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 or MATH 120 (or higher) or ALEKS score of 51 (or higher); or ACT Math sub-score of 28 or higher; or SAT Math sub-score of 660 or higher.

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 and 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 and E&C-ENGR 227.

Co-requisites: E&C-ENGR 228.

E&C-ENGR 241 Applied Engineering Analysis I Credits: 3
Prerequisites: MATH 220 or MATH 268 (with a grade of C or better).

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 or MATH 266; and PHYSICS 240 (both with a grade of C or better).

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 (or MATH 345 as a pre or co-req) with a grade of C or better.

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 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 276.

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, BJTs, 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 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. Recommended preparation: E&C-ENGR 276, E&C-ENGR 277.
\textbf{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.
\textbf{Prerequisites:} E&C-ENGR 241, E&C-ENGR 276.

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.
\textbf{Prerequisites:} E&C-ENGR 241 (with a grade of C or better).

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.
\textbf{Prerequisites:} E&C-ENGR 376.

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

\textbf{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.
\textbf{Prerequisites:} E&C-ENGR 277.

\textbf{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.
\textbf{Prerequisites:} E&C-ENGR 341R.

\textbf{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.
\textbf{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.
\textbf{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.
\textbf{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.
\textbf{Prerequisites:} Senior standing.

E&C-ENGR 402 Senior Design I Credits: 3
This is the first capstone design course in electrical and computer engineering providing and accounting for laboratory, library, research and other work needed for the development of the project and stresses oral presentations.
\textbf{Prerequisites:} E&C-ENGR 330 and (E&C-ENGR 428R or E&C-ENGR 466).
E&C-ENGR 403 Senior Design II  Credits: 2
This is the second capstone design course in electrical and computer engineering providing laboratory experience in prototyping, fabrication, and troubleshooting of the design project with stresses in written and oral presentation. Course topics include: project management, professional practice, ethical and engineering economic considerations and development of written and oral presentation skills.
Prerequisites: E&C-ENGR 402.

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). Recommended preparation: MATLAB proficiency.
Prerequisites: E&C-ENGR 302, E&C-ENGR 380, E&C-ENGR 381.

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.
Prerequisites: E&C-ENGR 216.

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 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 330.

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.
Prerequisites: E&C-ENGR 330.

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 330.

E&C-ENGR 453 Introduction to Wind Energy Systems Credits: 3
This course explores the power conversion and control of wind energy conversion systems (WECS) from the electrical engineering perspective. It provides a comprehensive and in-depth analysis of wind as a source of energy, aerodynamic of wind turbine, wind generators, system configurations, power converters, control schemes, and system design of various practical wind energy systems.
Prerequisites: E&C-ENGR 376

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.
Prerequisites: E&C-ENGR 330 or E&C-ENGR 334.

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 376.

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 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
This course includes the following topics: power system matrices, power flow analysis, Gauss-Seidel and Newton-Raphson techniques, fast-decoupled load flow, economic dispatch, voltage control system, and power system control. Prerequisites: 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 474 Introduction to Communication Systems Credits: 3
This course is an introduction to principles and fundamentals of communication systems and covers the following topics: signal representation and analysis, analog and digital modulation techniques, error control channel coding, properties of communications media, and overview of modern systems and latest cellular technology.
Prerequisites: COMP-SCI 394R, E&C-ENGR 380.

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 479 Introduction to Computer Vision Credits: 3
This course focuses on topics of computer vision, teaching computers how to understand images. Introductory topics include image formation, color and texture features, homograph, key points detection, aggregation, subspace methods in image modeling, and deep learning based image segmentation and classification, with applications in photography, media and entertainment, education, defense and medicine. The course is project based and emphasis hands on experiences for students to solve real world problems.
Prerequisites: E&C-ENGR 380

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: 0-6
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.
Prerequisites: Departmental consent.

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.
Prerequisites: Departmental consent.
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 5318 Dynamical Systems and Complex Networks Credits: 3
An overview of classical dynamical systems, and its application in different fields such as Electrical Engineering (nonlinear circuits), Network Sciences, Epidemiology, and Ecology will be discussed. Phenomena such as chaos, bifurcation, and limit cycles will be examined. This course will also introduce and develop the mathematical theory of Complex Networks with applications to network-driven phenomena in Um Internet, search engines, social networks, the World Wide Web, information and biological networks; spectral graph theory; models of networks including random graphs, preferential attachment models, and the small-world models.

E&C-ENGR 5501AP Special Topics In Electrical Engineering Credits: 1-4
E&C-ENGR 5501NN Special Topics In Electrical Engineering Credits: 1-4
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; microstripes and striplines; r.f. propagation in wireless and radar systems; conformal mapping techniques ad applications (optional). Recommended preparation: Knowledge in Engineering Computation, Technical Writing Skills. **Prerequisites:** E&C-ENGR 302, E&C-ENGR 380, E&C-ENGR 381.

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.

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 Verilog 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 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 5553 Wind Energy System Engineering Credits: 3
This course explores the power conversion and control of wind energy conversion systems (WECS) from the electrical engineering perspective. It provides a comprehensive and in-depth analysis of wind as a source of energy, aerodynamic of wind turbine, wind generators, system configurations, power converters, control schemes, and system design of various practical wind energy systems.

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, 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, E&C-ENGR 412.

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 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.

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 Computer Vision Credits: 3
The image is an essential form of information representation and communication in modern society. This course focuses on topics of computer vision, teaching computer how to understand images. Topics include image formation, color and texture features, key points detection, aggregation, subspace methods in image modeling, and deep learning image classification, with many applications in photography, media and entertainment, education, defense and medicine.

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, Gaussian 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 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
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 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 in Electrical and Computer Engineering Credits: 1-4
E&C-ENGR 5590IN Special Topics in Electrical and Computer Engineering
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
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
Special Topics in Electrical and Computer Engineering
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 5590T 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 area 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 5635 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 5647 Emerging Interdisciplinary Research in Nanotechnology Credits: 3
This cross-disciplinary course will focus on nanoscale materials, devices and circuit technologies, and its applications in the next generation computing, communication, electronics, biomedical, energy and environment sectors. The course will familiarize students with recent technological progresses and potential socio-economic impacts in the broader fields of nanotechnology. This will be a high level graduate course for students from diverse academic backgrounds. Instructor's prior approval is recommended.

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 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.

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 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.
Prequisites: COMP-SCI 201R.

INFO-TEC 372 Database Administration Credits: 3
This course covers, database administration, setup and tuning of DBMS. Not for Graduate credit.
Prequisites: 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.
Prequisites: COMP-SCI 420.

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.
Prequisites: 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.
Prequisites: Departmental consent.

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.
Prequisites: MATH 210, COMP-SCI 303, or equivalent.

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.
Prequisites: 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.
Prequisites: School of Computing and Engineering Student.

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 or 3D CAD 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.
Prequisites: Departmental consent.

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++.
Prequisites: MATH 266 (preferred) or MATH 220.

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.
Prequisites: MATH 268.
MEC-ENGR 272 Engineering Analysis 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 or MATH 220.

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 (preferred) or MATH 220; and PHYSICS 250.

MEC-ENGR 306 Numerical Analysis Credits: 3
Prerequisites: MEC-ENGR 272 or MATH 345; E&C-ENGR 216 or MATH 345L.

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 324L Engineering Materials Lab Credit: 1
Introduction to the laboratory techniques used in studying the physical and mechanical properties of engineering materials. The material testing in this course is primarily of metallic materials. Physical and mechanical property variations as a result of various processing techniques are studied. Recommended preparation: Machine Shop Safety. 
Co-requisites: MEC-ENGR 324.

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: MEC-ENGR 272 or MATH 345 and CIV-ENGR 275.

MEC-ENGR 352 Mechanical Instrumentation Lab Credits: 3
Static and dynamic errors: measurement and propagation of uncertainty; experiment design; instrumentation selection and calibration; measurement of voltage, resistance, amperage, displacement, velocity, acceleration, force, and strain 
Prerequisites: CIV-ENGR 276, Machine Shop Safety

MEC-ENGR 353 Heat Transfer and Fluid Mechanics Lab Credits: 2
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 351.

Co-requisites: MEC-ENGR 399.

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 Applied Thermodynamics 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. 
Co-requisites: MEC-ENGR 324L.
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 (or MATH 345), and MEC-ENGR 285.

MEC-ENGR 399 Heat Transfer Credits: 3
Prerequisites: MATH 250 or MEC-ENGR 270; and MEC-ENGR 299, MEC-ENGR 351.

MEC-ENGR 399L Heat Transfer and Fluids 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.
Prerequisites: Departmental consent.

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 399.

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 406 Introduction to Biomaterials Credits: 3
The course covers the basics of biomaterials science and principles of biological systems followed by characterization of biomaterials, tissue engineering and bioprinting application, and drug delivery and challenges in clinical applications.
Prerequisites: MEC-ENGR 285 or MEC-ENGR 299.

MEC-ENGR 407 Advanced Dynamics and Modeling Credits: 3
Fundamental principles of advanced rigid body dynamics with applications. Special mathematical techniques including Lagrangian and Hamiltonian methods.
Prerequisites: MEC-ENGR 285 and MEC-ENGR 306.

MEC-ENGR 411 Introduction to Biomechanics Credits: 3
This course is to provide students with an introduction to the engineering principles of biomechanics.
Prerequisites: MEC-ENGR 219 or E&C-ENGR 216; or MEC-ENGR 285.
Co-requisites: MATH 300 or CIV-ENGR 319.

MEC-ENGR 412 Biodynamics Credits: 3
Introduction to musculoskeletal biomechanics including: computational biomechanics, movement simulation, motor control and musculoskeletal tissues. Recommended preparation: 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 Control Systems Theory 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 416 Biomedical Device Design Credits: 3
Project based course which exposes students to the entire design process from problem definition to prototype validation for biomedical device applications. Projects in the course are sponsored by real clients from the local biomedical industry, medical clinicians, and/or research labs. The course will cover the following main components: Problem Definition, Concept Generation and Evaluation, Detailed Design, Prototyping and Testing, Project Management, Regulations and Standards, and Technical Communication. Prerequisites: Senior standing.
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 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.
Co-requisites: 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 459 Robotics and Unmanned Systems Credits: 3
Students will develop, implement, and evaluate various path following (point mass, rigid body, and Dubin's) and trajectory generation (configuration spaces, roadmaps, cell decomposition, etc.) concepts on simulation and experimental platforms.
Prerequisites: MEC-ENGR 306, MEC-ENGR 457.
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 462 Applied Computational Fluid Dynamics Credits: 3
The fundamentals of computational fluid mechanics. Introduction to the governing equations and boundary conditions of viscous fluid flows, turbulence and its modeling, and how to solve a fluid flow problem using commercially available CFD software.
Prerequisites: MEC-ENGR 351 or CIV-ENGR 351; MEC-ENGR 360.

MEC-ENGR 464 Turbomachines Credits: 3
This course covers the practical application of thermodynamics, fluid dynamics, and dimensional analysis to the design of pumps, fans, compressors, and turbines.
Prerequisites: MEC-ENGR 351 or CIV-ENGR 351; MEC-ENGR 360.

MEC-ENGR 466 Applied Optimization and Decision Modeling Credits: 3
Introduction to mathematical programming techniques and applications. Linear and integer programming, transportation 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 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 306, MEC-ENGR 385.

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: 0-6
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.
Prerequisites: Departmental consent.

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 or MEC-ENGR 131; senior standing.
Co-requisites: MEC-ENGR 356 and MEC-ENGR 324.

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 494 Robotic System Identification Credits: 3
Students will develop, implement, and evaluate various system identification and parameter estimation techniques. Students will quantify estimation accuracy through both theoretical and experimental exercises.
Prerequisites: MEC-ENGR 285, MEC-ENGR 306, MEC-ENGR 352.
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:** ANCH 309 or MEC-ENGR 492; MEC-ENGR 356.

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 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 5501MS 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 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 5506 Introduction to Biomaterials Credits: 3
The course covers the basics of biomaterials science and principles of biological systems followed by characterization of biomaterials, tissue engineering and bioprinting application, and drug delivery and challenges in clinical applications. Knowledge of engineering materials or thermodynamics is helpful.

MEC-ENGR 5507 Advanced Dynamics and Modeling Credits: 3
Fundamental principles of advance rigid body dynamics with applications. Special mathematical techniques including Lagrangian and Hamiltonian methods.

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 5516 Biomedical Device Design Credits: 3
Project based course which exposes students to the entire design process from problem definition to prototype validation for biomedical device applications. Projects in the course are sponsored by real clients from the local biomedical industry, medical clinicians, and/or research labs. The course will cover the following main components: Problem Definition, Concept Generation and Evaluation, Detailed Design, Prototyping and Testing, Project Management, Regulations and Standards, and Technical Communication.

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.
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.

MEC-ENGR 5533 Advanced 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.

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:** CIV-ENGR 211, MEC-ENGR 285.

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.

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.

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, Euler's angles, Euler's 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 5559 Robotics and Unmanned Systems Credits: 3
Students will develop, implement, and evaluate various path following (point mass, rigid body, and Dubin's) and trajectory generation (configuration spaces, roadmaps, cell decomposition, etc.) concepts on simulation and experimental platforms. **Prerequisites:** MEC-ENGR 306, MEC-ENGR 457.

MEC-ENGR 5562 Applied Computational Fluid Dynamics 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. Recommended preparation: MEC-ENGR 360 and MEC-ENGR 351.
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

MEC-ENGR 5564 Turbomachines Credits: 3
This course covers the practical application of thermodynamics, fluid dynamics, and dimensional analysis to the design of pumps, fans, compressors, and turbines. Recommended preparation: MEC-ENGR 360 and MEC-ENGR 351.

MEC-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.

MEC-ENGR 5567 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 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.

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.

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 5594 Robotic System Identification Credits: 3
Students will develop, implement, and evaluate various system identification and parameter estimation techniques. Students will quantify estimation accuracy through both theoretical and experimental exercises. Prerequisites: MEC-ENGR 285, MEC-ENGR 306, MEC-ENGR 352.
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 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 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.

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.

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

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.