THE SCHOOL OF ENGINEERING
http://www.uvm.edu/~cems/soe/

ENGINEERING CURRICULA
The College of Engineering and Mathematical Sciences offers ABET-accredited B.S. degrees in Civil, Electrical, Environmental, and Mechanical Engineering. In addition, the College offers three interdisciplinary degrees: the B.S. in Engineering, the B.S. in Engineering Management (offered in conjunction with the School of Business Administration), and the B.A. in Engineering (offered in conjunction with the College of Arts and Sciences).

LAPTOP REQUIREMENTS
Engineering is a professional field that leverages mathematics and the sciences to design and implement solutions to problems faced by society. The practicing Engineer utilizes not only the fundamentals related to mathematics and the sciences but also computational tools to accomplish his or her tasks. With the latter reality in mind, the School of Engineering (SoE) requires all incoming engineering students to have a laptop computer. The laptop requirement enables instructors to incorporate computational analysis and numerical examples in the classroom for an immediate and powerful praxis of engineering theory. The laptop requirement is platform agnostic (Windows, Mac or Linux). The suggested minimum configuration is available on the School of Engineering website. Note that current netbooks will not have sufficient computational resources to meet the requirements. As part of the laptop requirement, students must also purchase a student version of MATLAB® (a high-level programming language and interactive computational environment). MATLAB® is available through the MathWorks™ website. The school also recommends that students have word processing, presentation and spreadsheet software on their laptop.

HUMANITIES AND SOCIAL SCIENCE REQUIREMENTS
To complement the technical content of the engineering curriculum, all B.S. programs require a Humanities and Social Science (HSS) component that encourages the exploration of the Humanities and Social Sciences and the appreciation of diversity in society. HSS electives may not be taken on a pass/no pass basis. A minimum of fifteen credits are required and at least six credits must be from the same department. A current list of approved HSS electives is available on the CEMS Student Services website or in the CEMS Student Services office (Votey 301).

Students’ HSS electives must include two three-credit University Approved Diversity courses. One three-credit course must be from Category 1 (Race and Racism in the U.S.) and the second three-credit course can be from either Category 1 or Category 2 (Human and Societal Diversity). See the Diversity course listing in this catalogue. Diversity courses have a D1 or D2 prefix.

ACADEMIC STANDARDS FOR ENGINEERING
To continue as a major in the School of Engineering, a student must achieve a 2.30 cumulative grade-point average at the end of the semester in which thirty cumulative credits have been attempted. Note that this academic standard is more stringent than that of the rest of the college and some of the other colleges and schools within the university. No more than three repeated course enrollments are allowed during this thirty-credit period. In the case of transfer students, applicable transfer credits will be included in determining the thirty credits, but grades in these courses will not be included in the grade-point average.

Students who receive a cumulative or semester grade-point average of less than 2.30 will be placed on trial. Students who have failed half their course credits for any semester, or who have had two successive semester grade-point averages below 2.30, or three successive semesters in which their cumulative grade-point average falls below 2.30, are eligible for dismissal.

To receive a degree, students must have a minimum cumulative average of 2.30. Students must complete thirty of the last forty-five credits in residence at UVM as matriculated students in the College of Engineering and Mathematical Sciences. Additional degree requirements are specified for each major.

No more than one grade of D, D+, or D- will be acceptable in any engineering (CE, EE, EMGT, ENGR and ME) courses. Requirements in each program are specified by the respective program curriculum committees.

A course may not be taken for credit if it is a prerequisite to one for which credit has already been granted, except by permission of the student’s advisor.

PRE-ENGINEERING TECHNICAL (PET) REQUIREMENT
The Pre-Engineering Technical (PET) requirement consists of nineteen credits to be completed nominally by the end of the student’s first year with no grade lower than C-. Transfer students entering the sophomore year engineering curriculum must complete the PET requirement during their first semester at UVM. Transfer students are encouraged to make up missing courses during the summer preceding their arrival at UVM.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>MATH 021</td>
<td>Calculus I</td>
<td>4</td>
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<tr>
<td>MATH 022</td>
<td>Calculus II</td>
<td>4</td>
</tr>
<tr>
<td>CHEM 031</td>
<td>General Chemistry I</td>
<td>4</td>
</tr>
<tr>
<td>CS 020</td>
<td>Programming for Engineers</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 031</td>
<td>Physics for Engineers I</td>
<td>4</td>
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Successful completion of the PET requirement is prerequisite to taking any of the following engineering courses that are typically taken in the sophomore year. Students will be disenrolled from these courses if the PET requirement has not been successfully completed.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
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<tbody>
<tr>
<td>EE 003</td>
<td>Linear Circuit Analysis I</td>
<td>3</td>
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<tr>
<td>EE 004</td>
<td>Linear Circuit Analysis II</td>
<td>0 or 3</td>
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<tr>
<td>EE 081</td>
<td>Linear Circuits Laboratory I</td>
<td>0 or 2</td>
</tr>
<tr>
<td>EE 082</td>
<td>Linear Circuits Laboratory II</td>
<td>0 or 2</td>
</tr>
<tr>
<td>EE 100</td>
<td>Electrical Engr Concepts</td>
<td>0 or 4</td>
</tr>
<tr>
<td>EE 131</td>
<td>Fundamentals of Digital Design</td>
<td>3</td>
</tr>
<tr>
<td>EE 134</td>
<td>Microcontroller Systems</td>
<td>4</td>
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<tr>
<td>CE 001</td>
<td>Statics</td>
<td>0 or 3</td>
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<tr>
<td>CE 010</td>
<td>Geomatics</td>
<td>0 or 4</td>
</tr>
<tr>
<td>CE 132</td>
<td>Environmental Systems</td>
<td>3</td>
</tr>
<tr>
<td>ME 012</td>
<td>Dynamics</td>
<td>3</td>
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<tr>
<td>ME 014</td>
<td>Mechanics of Solids</td>
<td>3</td>
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<tr>
<td>ME 040</td>
<td>Thermodynamics</td>
<td>3</td>
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<td>ME 042</td>
<td>Applied Thermodynamics</td>
<td>3</td>
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<tr>
<td>ME 081</td>
<td>Mech Engr Shop Experience</td>
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<tr>
<td>ME 083</td>
<td>Computational Mech. Engr. Lab</td>
<td>1</td>
</tr>
</tbody>
</table>

**ACCELERATED MASTER’S PROGRAMS IN ENGINEERING**

Qualified undergraduate students who plan to earn a master’s degree in Civil and Environmental, Electrical, or Mechanical Engineering may enroll in the Accelerated Master’s program, which enables a student to begin working on a master’s degree while still an undergraduate. Students apply for the Accelerated Master’s program in the second semester of their junior year. Upon entering the Accelerated Master’s program, a student may take up to nine credits of courses for graduate credit while still an undergraduate. Of these, up to six credits of 200-level or higher courses can be counted toward both the B.S. and the M.S. degrees, subject to approval of the student’s graduate advisor. Students in the Accelerated Master’s program typically begin work toward their master’s thesis starting in the summer following their junior year. To apply for the Accelerated Master’s program, students must have a cumulative grade-point average of at least 3.20 at the time of application, must submit a letter of application to the graduate program coordinator naming a faculty member who has agreed to serve as their graduate advisor, and must complete the Graduate College application.

The Accelerated Master’s program is only available for Electrical Engineering and Mechanical Engineering students who are planning a thesis-based degree. Those pursuing a M.S. degree in Civil and Environmental Engineering may choose either a thesis-based or non-thesis based program.

**MAJORS**

**ENGINEERING MAJORS**

- Civil Engineering B.S.CE.
- Electrical Engineering B.S.EE.
- Engineering B.A.E.
- Engineering B.S.E.
- Engineering Management B.S.EM.
- Environmental Engineering B.S.EV.
- Mechanical Engineering B.S.ME.

**MINORS**

**ENGINEERING MINOR**

- Electrical Engineering
- Geospatial Technologies Minor

**GRADUATE**

- Bioengineering Ph.D.
- Civil and Environmental Engineering AMP
- Civil and Environmental Engineering M.S.
- Civil and Environmental Engineering Ph.D.
- Electrical Engineering AMP
- Electrical Engineering M.S.
- Electrical Engineering Ph.D.
- Mechanical Engineering AMP
- Mechanical Engineering M.S.
- Mechanical Engineering Ph.D.

See the online Graduate Catalogue for more information.

**Civil Environmental Engr Courses**

- **CE 001. Statics. 0 or 3 Credits.**
  Fundamentals of statics; composition and resolution of forces; the analysis of force systems in two and three dimensions; and centroids and moments of inertia. Prerequisites: Pre-Engineering Technical (PET) Core Completion.
CE 002. CE Graphic Design. 0 or 3 Credits.
Computer-aided and hand generation of: geometric shapes; dimensioning; pipe drafting; foundations and structures; survey plots; graphs and charts; topography; and highway geometry.

CE 003. Intro to Civil & Envir Engr. 0 or 2 Credits.
Introduces Civil and Environmental Engineering through hands-on-design, group projects, inquiry-based learning, systems thinking, critical thinking, and computational exercises.

CE 010. Geomatics. 0 or 4 Credits.
An introduction to surveying including distance and angle measurements, leveling, traverse surveys, error propagation, topographical mapping, global positioning systems (GPS), and geographic information systems (GIS). Prerequisites: Pre-Engineering Technical (PET) Core Completion.

CE 095. Special Topics. 1-18 Credits.
See Schedule of Courses for specific titles.

CE 100. Mechanics of Materials. 0 or 3 Credits.
Stress, strain, temperature relationships, torsion, bending stresses, and deflections. Columns, joints, thin-walled cylinders. Combined stresses and Mohr’s circle. Prerequisite: CE 001. Co-requisite: MATH 121. Cross-listed with: ME 014.

CE 101. Materials and Structures Lab. 3 Credits.
Experimental stress analysis methods; experimental verification of static force-displacement relationship for beams, frames and trusses; fundamental mechanical properties of metals, plastics, and wood; effects of size, shape, method, speed of loading and strain history on these properties. Co-requisites: CE 100 and CE 170.

CE 132. Environmental Systems. 3 Credits.
Systems thinking and the systems approach as applied to environmental systems with linkages to transportation; feedback and emergent properties; systems modeling; economics; environmental engineering introduction (mass balance, hydrology, air pollution). Prerequisite: Pre-Engineering Technical (PET) Core Completion.

CE 133. Transportation Systems. 3 Credits.
Transportation systems planning, analysis, and design with focus on safety, modeling, decision support, and environmental impacts. Prerequisites: CE 132. Co-requisite: CE 010.

CE 134. Sustainable Eng. Economics. 0 or 3 Credits.
A framework for applying systems analysis tools to engineering economic decision analysis to address the environmental impacts, energy efficiency and cost effectiveness with applications to climate change needed for sustainable engineering solutions. Prerequisite: CE 132. Co-requisite: CS 020.

CE 140. Transportation. 3 Credits.
Analysis of transportation systems; technological characteristics; the transportation planning process and techniques of travel modeling and forecasting for both urban and rural areas. Prerequisite: CE 010; Junior standing in CE, or Instructor permission.

CE 150. Environmental Engineering. 3 Credits.
Basic phenomena and theoretical principles underlying water supply, air and water pollution control, and industrial hygiene. Prerequisite: CHEM 031 or CHEM 025, MATH 022.

CE 151. Water & Wastewater Engineering. 3 Credits.
Design of treatment systems for water supply, groundwater remediation, domestic and hazardous wastewater, sewer design; semester-long design projects; ethics; environmental health impacts; governmental regulations. Co-requisite: CE 132.

CE 160. Hydraulics. 0 or 4 Credits.
Mechanics of incompressible fluids; flow meters; flow in closed conduits and open channels; elements of hydraulic machinery; laboratory studies of flow and hydraulic machinery. Prerequisites: CE 001, MATH 121. Co-requisites: MATH 271, CS 020 or CS 016.

CE 170. Structural Analysis. 0 or 3 Credits.
Analysis of statically indeterminate beams, frames, and trusses; expected loads, reactions; influence lines; moving loads; geometric methods for displacement calculations; introduction to matrix analysis for trusses. Prerequisites: CE 100, MATH 271, CS 020.

CE 172. Structural Steel Design. 3 Credits.
Theory and design of steel structures including flexural members, axially loaded members and combined stress members; design of composite members; and plastic analysis and design. Prerequisite: CE 170.

CE 173. Reinforced Concrete. 3 Credits.
Analysis of stresses in plain and reinforced concrete members; design of reinforced concrete structures; and theory of prestressed concrete. Prerequisite: CE 170.

CE 175. Senior Design Project. 0 or 3 Credits.
Student teams will integrate the multiple areas of specialization in Civil/Environmental Engineering in comprehensive design experience; professional practice; ethics; written and oral presentations to professional review panels. Prerequisite: Senior Standing.

CE 180. Geotechnical Principles. 0 or 4 Credits.
Characteristics and classification of soils; physical, mechanical and hydraulic properties of soils; seepage; the effective stress principle; stress distribution, consolidation, settlement; shear strength; laboratory testing. Prerequisite: CE 100.

CE 191. Special Projects. 3 Credits.
Investigation of special topic under guidance of faculty member. Library investigations, unique design problems, laboratory and field studies. Prerequisite: Senior standing; Department permission.

CE 192. Special Projects. 3 Credits.
Investigation of special topic under guidance of faculty member. Library investigations, unique design problems, laboratory and field studies. Prerequisite: Senior standing; Department permission.

CE 193. College Honors. 1-6 Credits.

CE 194. College Honors. 1-6 Credits.
CE 195. Special Topics. 1-18 Credits.
See Schedule of Courses for specific titles. Prerequisite: Senior standing in Civil Engineering.

CE 218. Numerical Methods for Engineer. 3 Credits.
Foundational concepts of numerical integration, numerical differentiation, and numerical approximation and solution of differential and partial differential equations of the type encountered in the analysis of engineering problems and data processing. Prerequisites: MATH 271, CS 020, MATH 124. Cross-listed with: ME 218.

CE 220. Intro to Finite Element Anyl. 3 Credits.
Introduction to finite element analysis: applications in solid mechanics, hydrodynamics, and transport: analysis of model behavior: Fourier analysis. Computer project required. Prerequisites: computer programming, linear algebra, or permission of Instructor.

CE 226. Civil Engineering Systems Anyl. 3 Credits.
Linear programming, dynamic programming, network analysis, simulation; applications to scheduling, resource allocation, routing, and a variety of civil engineering problems. Prerequisites: Senior/Graduate standing in Civil & Environmental Engineering or Instructor permission. Cross-listed with: CSYS 226.

CE 241. Traffic Operations & Design. 3 Credits.
Advanced concepts of traffic engineering and capacity analysis; highway and intersection capacity; traffic analysis and simulation software; design and application of controls. Prerequisite: CE 133.

CE 245. Intelligent Transportation Sys. 3 Credits.
Introduction to Intelligent Transportation Systems (ITS), ITS user services, ITS applications, the National ITS architecture, ITS evaluation, and ITS standards. Pre/co-requisites: CE 140 or equivalent; Instructor permission. Cross-listed with: CSYS 245.

CE 247. Alt Sustainable Waste Treatmnt. 3 Credits.
Consideration of cultural paradigms that encourage waste generation. Design of alternative treatment systems including composting, constructed wetlands, anaerobic digestion. Research and hands-on design project. Prerequisite: CE 151.

CE 248. Hazardous Waste Mgmt Engr. 3 Credits.
Management of hazardous and industrial waste from generation to disposal; emphasis on pollution prevention within industry; waste minimization, recovery, reuse, treatment technologies; environmental regulations, risk assessment, costs and public policy; group projects. Prerequisite: Senior standing in Engineering or sciences.

CE 249. Solid Wastes. 3 Credits.
Significance of solid wastes from municipal, industrial, agricultural, mining; optimization and design of collection, disposal, recycle systems; sanitary landfills, incineration, composting, material recovery. Prerequisites: CHEM 025, PHYS 021.

CE 250. Fate/Transport Organic Chem. 3 Credits.
Chemical transfers between environmental media; molecular structure-reactivity models; chemical, photochemical and biochemical transformation rates; emphasis on predicting environmental concentrations and risk. Graduate student independent modeling project. Prerequisites: CHEM 031, CHEM 032, CE 132.

CE 251. Envr Facility Dsgn/Wastewater. 3 Credits.
Design of wastewater conveyance and treatment facilities; sewage treatment plant design; equipment selection. Prerequisite: CE 151.

CE 253. Transportation & Air Quality. 3 Credits.
Air pollution sources, measurement methods, legislation, vehicle emissions formation, control and transport processes. Emphasis on emission factor and dispersion multi-scale modeling using latest modeling tools. Prerequisite: CE 133.

CE 254. Environmental Quantitive Anyl. 0 or 4 Credits.
Course focuses on chemical, biochemical and physical processes; diffusion, equilibria, reaction kinetics, acids/bases, colloids, air/water exchange; laboratories demonstrate standard environmental engineering techniques. Prerequisites: CHEM 032, CE 132, STAT 141 or STAT 143.

CE 255. Phys/Chem Proc Water/Wstwater. 0 or 3 Credits.
Theory of physical/chemical processes for treating waters and wastewaters; reactor dynamics, mass transfer, adsorption, ion exchange, precipitation. Pre/co-requisites: CE 151, CE 154, or permission of Instructor.

CE 256. Biol Proc Water/Wastewater Tr. 0 or 3 Credits.
Theory and application of biological processes for treating industrial and domestic wastewaters and contaminated ground water; microbiological considerations; aerobic and anaerobic processes; reactor design, in-situ bioremediation; bench-scale and pilot-scale experimentation. Prerequisite: CE 151.

CE 259. Msmt of Airborne Contaminants. 3 Credits.
Quantifying airborne contaminants from processes and ambient levels. Laboratories demonstrate calibration and measurement, stack sampling and ambient air monitoring, and specific contaminant generation and measurement. Prerequisite: CE 252 or CE 253.

CE 260. Hydrology. 3 Credits.
Theory of precipitation, run-off, infiltration, and ground water; precipitation and run-off data; and application of data for use in development of water resources. Prerequisite: CE 160.

CE 261. Open Channel Flow. 3 Credits.
Application of the laws of fluid mechanics to flow in open channels; design of channels and transition structures; modeling; uniform and gradually-varied flows. Prerequisite: CE 160.

CE 265. Ground Water Hydrology. 3 Credits.
Principles of ground water hydraulics, well characteristics, aquifers, and use of numerical methods to solve ground water flow problems. Prerequisite: CE 160.
CE 271. Advanced Structural Analysis. 3 Credits.
Virtual work, energy theorems, analysis of structures by the
displacement method, finite element analysis of structural systems,
non-linear structural analysis, structural optimization, probalistic
structural analysis. Prerequisite: CE 170.

CE 272. Structural Dynamics. 3 Credits.
Vibrations, matrices, earthquake engineering, stability and wave
propagation. Prerequisites: Senior or Graduate standing in
Engineering or physical sciences, or Instructor permission. Cross-
listed with: ME 270.

CE 273. Structural Design - Wood. 3 Credits.
Analysis and design of solid and glue laminated timber members
and structural systems including tension members, beams, columns,
beam-columns, diaphragms, shear walls and connections; LRFD and
ASD design methods; application of IBC for timber systems; current
developments in wood design/construction. Prerequisite: CE 170.

CE 281. Geotechnical Design. 3 Credits.
Subsurface explorations; bearing capacity, lateral earth pressures,
slope stability; analysis and design of shallow and deep foundations,

CE 283. Designing with Geosynthetics. 3 Credits.
Geotextiles, geogrids, geonets, geomembranes, geocomposites,
geopipes. Design for separation, reinforcement, filtration, drainage,
erosion, control, liners. Applications in transportation, drainage, solid
waste containment. Material testing, behavior. Prerequisite: CE 180.

CE 284. Site Characterization. 3 Credits.
A comprehensive approach to subsurface site characterization for
technical and environmental designs and a systems approach for
integrating the two. Prerequisites: CE 160, CE 180.

CE 285. Geo-energy Systems. 3 Credits.
An introduction to Geoenergy technologies for subsurface energy
extraction (shallow and deep geothermal systems, enhanced oil
recovery, shale gas extraction) and secure storage of byproducts of
energy production (carbon dioxide and nuclear wastes). Prerequisite:
CE 180.

CE 290. Engineering Investigation. 3 Credits.
Independent investigation of a special topic under the guidance of a
staff member. Preparation of an engineering report is required.

CE 295. Special Topics. 1-18 Credits.
Content is dictated by expanding professional interest in newly
developing, or recently developed, technical areas in which there
is particular need or opportunity. Prerequisite: Senior/Graduate
standing.

Electrical Engineering Courses
EE 001. First-year Design Experience. 0 or 2 Credits.
Introduction to the engineering profession and design. Hands-on
experiences that emphasize interdisciplinary teamwork, technical
communications, and project design methodologies. Cross-listed
with: ME 001.

EE 003. Linear Circuit Analysis I. 3 Credits.
Circuit elements, laws, and analysis. Network principles and
Transient analysis and time constants. Prerequisite: MATH 022.

EE 004. Linear Circuit Analysis II. 0 or 3 Credits.
Sinusoids and phasors. Sinusoidal steady-state response and power.
Complex frequency and network functions. Resonance. Laplace
transform techniques. Fourier series and Fourier transforms.
Prerequisite: EE 003. Co-requisite: MATH 271.

EE 081. Linear Circuits Laboratory I. 0 or 2 Credits.
Electrical instruments; oscilloscope measurements; resistive,
capacitive, and inductive components; applications of operational
amplifiers; digital-to-analog converters; transient response of RL and

EE 082. Linear Circuits Laboratory II. 0 or 2 Credits.
Transients in RLC circuits; steady state sinusoidal response in RLC
circuits; real and reactive power in RLC circuits; operational amplifier
active filters. Prerequisite: EE 081. Co-requisite: EE 004.

EE 095. Special Topics. 1-3 Credits.
See Schedule of Courses for specific titles. Prerequisite: Department
permission.

EE 100. Electrical Engr Concepts. 0 or 4 Credits.
Fundamentals of electrical engineering; DC and AC linear circuit
analysis; laboratory component. No credit for Electrical Engineering
majors. Co-requisite: PHYS 125.

EE 101. Digital Control w/ Embedded Sys. 0 or 4 Credits.
Applications of single-chip microcomputers as embedded systems
for data acquisition/real time control. Assembly language; parallel
and serial ports; timers; counters; A/D and D/A. Laboratory.
Prerequisite: EE 100.

EE 113. Electric Energy Systems. 0-4 Credits.
Energy sources, including renewables; generation, delivery,
consumption of electricity; power plants, emissions, policy; three-
phase power, transformers, motors/generators, power electronics;
0 credit laboratory included. Prerequisite: EE 100. Co-requisite: EE
004.

EE 120. Electronics I. 0 or 3 Credits.
Theory of operation of diodes and MOS transistors. DC and transient
analysis using diodes and transistors. NMOS and CMOS logic
circuits and memory cells. Circuit simulation software. Prerequisite:
EE 004.

EE 121. Electronics II. 0 or 3 Credits.
Bipolar transistor circuits. DC and high frequency amplifier design
using MOS and bipolar transistors. Feedback, oscillators, and
stability criteria. Operational amplifiers and switched capacitor filters.
Prerequisite: EE 120.
EE 131. Fundamentals of Digital Design. 3 Credits.
Combinational logic simplification and design, MSI and PLD components, synchronous and asynchronous sequential design, algorithmic state machines, registers, counters, memory units, introduction to hardware design languages. Prerequisite: Sophomore standing.

EE 134. Microcontroller Systems. 0 or 4 Credits.
Operation and applications of microcontrollers in embedded digital systems for real-time control and data acquisition. Programming and the design of interfaces. Prerequisites: EE 003 or EE 100; CS 020 or CS 021; CS 031.

EE 141. Electromagnetic Field Theory. 0 or 4 Credits.
Fundamentals of electromagnetic field theory, vector analysis, electric and magnetic fields, potential theory, boundary conditions and boundary value problems, Maxwell-Lorentz theory. Prerequisites: PHYS 125, MATH 271, EE 004.

EE 163. Solid State Phys Electronics I. 4 Credits.
Physical principles required to understand the operation of common semiconductor devices. Physical models of p-n junctions, Schottky barriers, and MOS field-effect transistors. Prerequisite: PHYS 042 with PHYS 022; MATH 271.

EE 164. Solid St Phys Electronics II. 3 Credits.

EE 171. Signals & Systems. 0 or 4 Credits.
Discrete and continuous-time signals and systems. Input/output descriptions and analysis. Convolution, Fourier analysis and Laplace transforms, Sampling and z-transforms. Application to electrical engineering design problems. Prerequisite: EE 004.

EE 174. Communication Systems. 0 or 4 Credits.

EE 183. Electronics Laboratory I. 0 or 2 Credits.
Characteristics and applications of diodes and MOSFETs; CMOS inverters and logic characterization; applications of operational amplifiers. Co-requisite: EE 120.

EE 184. Electronics Laboratory II. 0 or 2 Credits.
Characteristics and applications of bipolar junction transistors; medium frequency and differential amplifiers; operational amplifier output stages; analog and digital filters. Prerequisite: EE 183. Co-requisite: EE 121.

EE 187. Capstone Design I. 3 Credits.
Project management, professional ethics, social/economic impact, and contemporary issues that arise in engineering practice. Interdisciplinary project development including project selection, design requirements, prototyping and communications. Pre/co-requisite: Senior standing.

EE 188. Capstone Design II. 2 Credits.

EE 193. College Honors. 3-6 Credits.
EE 194. College Honors. 3-6 Credits.
EE 195. Special Topics. 1-18 Credits.
See Schedule of Courses for specific titles. Prerequisite: Department permission.

EE 207. Introductory Bioengineering. 3 Credits.
Introduction to biomedical engineering science including biomechanics, biomaterials, biomedical imaging, rehabilitation engineering, biomedical computing, biomedical instrumentation, and transport phenomena. Pre/co-requisites: Senior/Graduate standing in engineering; Instructor permission. Cross-listed with: ME 207.

EE 209. Transient Phenomena. 3 Credits.
Study of complex variable basis of Laplace and Fourier Transforms; applications to transient behavior of lumped and distributed parameter systems, root locus. Nyquist criterion and two-dimensional field problems. Prerequisite: MATH 271.

EE 210. Control Systems. 3 Credits.
Analysis and design of continuous and discrete-time control systems; stability, signal flow, performance criteria, classical and state variable methods, simulation design tools, computer-based realizations. Prerequisites: EE 171 or ME 111. Cross-listed with: ME 210.

EE 212. Computer Vision. 3 Credits.
Introduction to computer vision systems for interactive and industrial applications using both hard/software computational approaches. Pre/co-requisites: MATH 124 or MATH 271 and CS 026, or Instructor permission. Cross-listing: CS 212.

EE 215. Electric Energy Systems Analys. 3 Credits.
Transmission line, generator, transformer modeling and control, per-unit conversion, power flow calculations and software, symmetric components and fault analysis, protection/relaying, stability analysis, smart grid. Prerequisite: EE 113. Co-requisite: MATH 124.

EE 221. Prin VLSI Digital Circuit Des. 0 or 3 Credits.
Design of VLSI circuits using a modular approach with industrial grade software: schematic capture; circuit design languages (HDL); full-custom layouts; mixed signals; synthesis. Laboratory. Pre/co-requisites: EE 131, EE 163, EE 121.
EE 222. Prin VLSI Analog Cir Design. 0 or 3 Credits.
The design, layout, and simulation of VLSI analog circuits. Emphasis on small signal models and circuits used in operational amplifiers. Prerequisites: EE 163, EE 121, Instructor permission.

EE 224. Principles VLSI System Design. 3 Credits.

EE 227. Biomed MeasmntsInstrum & Sys. 3 Credits.
Biomedical and clinical engineering in research, industry, and health care institutions. Measurement techniques and instrumentation. Integrated biomedical monitoring, diagnostic, and therapeutic systems. Co-requisites: EE 121, ANPS 020; Instructor permission. Alternate years.

EE 228. Sensors. 3 Credits.
Sensor design, interrogation, and implementation. A wide variety of electrical, electronic, optical, mechanical, and cross-disciplinary devices. System designs, measurement techniques, and methodologies. Prerequisites: Senior standing in Engineering or Physics.

EE 231. Digital Computer Design I. 3 Credits.
Hardware organization and realization, hard-wired and microprogrammed control units, interrupt and I/O systems. Hardware design language introduced and used for computer design. Prerequisites: EE 131, either EE 134 or CS 101.

EE 232. Digital Computer Design II. 3 Credits.
Memory designs, error control, high-speed addition, multiplication, and division, floating-point arithmetic, cpu enhancements, testing and design for testability. Prerequisites: EE 231.

EE 233. Microprocessor Systems & Appl. 0 or 4 Credits.
Basic principles of mini/microcomputers; A/D; D/A; channels, magnetic devices, display devices, mechanical devices; interface designs of analog systems to mini/microcomputers; principles of microprogramming; bit-slice-based microcomputers. Prerequisites: Department permission; CS 101 desirable.

EE 241. Electromagnetic Wave Theory. 3 Credits.
Electromagnetic radiation and wave propagation in complex media and systems: angular spectrum of plane waves, dispersive pulse propagation, applications to communications, imaging and remote sensing. Prerequisite: EE 141 or equivalent.

EE 245. Quantum Electronics. 3 Credits.
A theoretical description of light-matter interactions in photon emitting resonant cavities. A practical understanding of laser design and operation. Prerequisite: EE 141.

EE 247. Physical Optics. 3 Credits.

EE 250. Test Engineering. 3 Credits.
Parametric, structural, functional, characterization and stress testing of components and subsystems. Test methods, strategies, planning, and economics. Test equipment hardware and software. Prerequisites: EE 121, EE 131.

EE 251. Digital Syst Testing & Design. 3 Credits.
Circuit failures, fault models, testing and test pattern generation, logic and fault simulation, design for testability, scan design, test interfaces, design for built-in self-test. Prerequisite: EE 131.

EE 261. Solid State Mat & Devices I. 3 Credits.

EE 262. Solid State Mats & Devices II. 3 Credits.

EE 266. Science & Tech Integrated Cir. 3 Credits.
Science and technology of integrated circuit fabrication. Interaction of processing with material properties, electrical performance, economy, and manufacturability. Prerequisites: EE 163 or EE 261; concurrent registration in EE 164 or EE 262.

EE 272. Information Theory. 3 Credits.
Introduction to probability concepts of information theory; entropy of probability models; theoretical derivations of channel capacity; coding methods and theorems, sampling theorems. Prerequisites: STAT 143/STAT 151/STAT 153.

EE 273. Digital Communications. 3 Credits.
Digital modulation/demodulation methods and BER performance; source entropy and channel capacity; optimal detection; convolutional codes and decoding algorithms. Pre/co-requisites: EE 174 and STAT 151.

EE 274. Intro Wavelets & Filter Banks. 3 Credits.

EE 275. Digital Signal Processing. 3 Credits.
Sampling and reconstruction of signals. DFT, FFT and the z-transform. FIR and IIR filter design. Speech coding. Accompanying lab: EE 289. Pre/co-requisites: EE 171; Instructor permission.

EE 276. Image Processing & Coding. 3 Credits.
Image enhancement techniques by point and spatial operations. Data compression techniques to include scalar quantization, entropy coding, transform and sub-band coding. Labs on PC hardware; PC and Unix-based software. Prerequisite: EE 275.
EE 277. Image Analysis & Pattern Recognition. 3 Credits.

EE 278. Wireless Communication. 3 Credits.
Modern wireless systems, including cellular design, propagation modeling, multiple access and equalization techniques. Pre/co-requisites: EE 174 and STAT 151.

EE 281. Materials Science Seminar. 1 Credit.
Presentation and discussion of advanced electrical engineering problems and current developments. Prerequisite: Senior or Graduate Engineering enrollment.

EE 282. Seminar. 1 Credit.
EE 283. Seminar. 1 Credit.
EE 284. Seminar. 1 Credit.

EE 289. Digital Signal Processing Lab. 1-3 Credits.
Design and microprocessor implementation of real-time digital signal processing systems. PC-based evaluation module and development tools. Experiments include sampling, digital filtering, and the FFT. Pre/co-requisite: EE 171.

EE 295. Special Topics. 0-18 Credits.
See Schedule of Courses for specific titles.

EE 320. Digital Signal Processing. 3 Credits.

Engineering Management Courses
EMGT 175. The Management of Technology. 3 Credits.
Role of technology in industry, the nature of technological change, strategies, management, research and development, forecasting, product service/project selection, development, management, transition to market, and evaluation. Prerequisites: Senior standing or Instructor permission.

EMGT 176. Plant Planning and Design. 4 Credits.
Analysis of facilities and services requirements, material handling, office and clean room layout, mathematical and computer techniques, safety and plant conservation. Prerequisites: Junior standing in Engineering or Business Administration or Instructor permission.

EMGT 185. Senior Project. 3 Credits.
Individual management engineering study designed to the particular interest of the student, utilizing and synthesizing the student’s engineering management education experience. Prerequisite: Senior standing in EMBA.

EMGT 195. Special Topics. 1-6 Credits.
Specialized or experimental course offered as resources permit.

Engineering Courses
ENGR 001. First-Year Design Experience. 2 Credits.
Introduction to the engineering profession and design. Hands-on experiences that emphasize interdisciplinary teamwork, technical communications, and project design methodologies.

ENGR 002. Graphical Communication. 0 or 2 Credits.
Principles of computer-aided drafting/design; production of engineering drawings including: orthographic, auxiliary, section, pictorials and dimensioning, graphics and charts; applications in specific engineering disciplines.

ENGR 010. D1:Diversity Issues: Math/Sci/Egr. 3 Credits.
Diversity in CEMS: under-representation, environmental justice, gender/race participation, ethical considerations, urban planning, equal opportunity, Title IX. Landscape of race/gender in STEM.

ENGR 020. Programming for Engineers. 3 Credits.
Introduction to computer programming principles using MATLAB, with applications chosen from civil, electrical, environmental, and mechanical engineering. Co-requisite: MATH 021. Cross-listed with: CS 020. Credit not given for both CS 016 and CS 020/ENGR 020.

ENGR 095. Special Topics. 0-18 Credits.
See Schedule of Courses for specific titles.

ENGR 101. Engineering Communications. 3 Credits.
Traditional technical and scientific writing forms, including outlines, summaries, abstracts, technical descriptions, research reports/papers and proposals; written and oral technical communication with technical and nontechnical audience; electronic professional portfolio. Prerequisites: ENGS 001; Engineering major.

ENGR 195. Special Topics. 1-18 Credits.
See Schedule of Courses for specific titles.

ENGR 201. Ethics in CEMS Rsrch/Practice. 1 Credit.
Professional responsibilities of computer scientists, engineers, mathematicians and statisticians in research and practice. Professional rights and responsibilities, research integrity, fair credit in research and publication. Prerequisite: Senior/Graduate standing.

ENGR 295. Special Topics. 1-18 Credits.
See Schedule of Courses for specific titles.

ENGR 296. Special Topics. 1-18 Credits.
See Schedule of Courses for specific titles.

MECH 001. First-Year Design Experience. 0 or 2 Credits.
Introduction to the engineering profession and design. Hands-on experiences that emphasize interdisciplinary teamwork, technical communications, and project design methodologies. Cross-listed with: EE 001.

MECH 012. Dynamics. 3 Credits.
Kinematics and kinetics of particles and rigid bodies in two and three dimensions. Computer-aided analysis. Prerequisite: CE 001, MATH 121.
ME 014. Mechanics of Solids. 3 Credits.
Stress, strain, temperature relationships, torsion, bending stresses and deflections. Columns, joints, thin-walled cylinders. Combined stresses and Mohr’s circle. Prerequisite: CE 001, MATH 121, ME 012, or concurrent enrollment. Cross-listed with: CE 100.

ME 040. Thermodynamics. 3 Credits.
Principles of engineering thermodynamics; applications of these principles to thermodynamic cycles. Prerequisites: MATH 022, PHYS 031 with PHYS 021.

ME 042. Applied Thermodynamics. 3 Credits.
Analysis of isentropic processes, gas, vapor and combined power cycles; refrigeration/heat pump cycles; relationships for ideal and real gases; gas mixtures and psychrometric applications. Prerequisite: ME 040.

ME 044. Heat Transfer. 1 Credit.

Introduction to finite element analysis, solid modeling, and stress-strain analysis with post-processing techniques. Online course. Prerequisite: ME 014 or ME 101.

ME 095. Special Topics. 0-3 Credits.
See Schedule of Courses for specific titles. One to three hours with Instructor approval.

ME 101. Materials Engineering. 3 Credits.
Atomic structure, crystalline structure, mechanical properties and testing of materials, phase equilibria, processing of metals, polymers, and ceramics. Prerequisite: ME 014.

ME 114. Intro Engineering Mechanics. 3 Credits.
Introduction to statics, dynamics, fluid mechanics, strength of materials, thermodynamics. Prerequisite: Junior standing in engineering or physical sciences.

ME 123. Thermo-Fluid Lab. 0 or 2 Credits.
Engineering measurements, data analysis and theory of experimentation. Experiments with fluids and material testing machines and instrumentation for dynamic measurements. Co-requisite: ME 143.

ME 124. Materials and Mechanics Lab. 0 or 2 Credits.

ME 142. Applied Thermodynamics. 3 Credits.
Analysis of isentropic processes, gas, vapor and combined power cycles; refrigeration/heat pump cycles; relationships for ideal and real gases; gas mixtures and psychrometric applications. Prerequisite: ME 040.

ME 144. Heat Transfer. 3 Credits.
One- and two-dimensional steady and unsteady thermal conduction; natural and forced internal and external convection; thermal radiation; heat exchangers; boiling and condensation heat transfer. Prerequisite: ME 143.

ME 150. The Engineering Profession. 3 Credits.
Professional practice of engineering. Laws, ethics, engineering economy, liability, insurance, and contracts. Prerequisite: Senior standing or Instructor permission.

ME 161. Modern Manufacturing Processes. 3 Credits.
Product development, product design, concurrent engineering, rapid prototyping, semiconductor manufacturing, metal and plastic products manufacturing, EDM, ECM, laser, ultrasonic and high energy forming methods, biotechnology. Prerequisite: Senior standing in Mechanical Engineering or Engineering Management.

ME 162. Modern Manufacturing Systems. 3 Credits.
Overview of systems used in manufacturing and operations management methods, including: quality systems, material management, lean manufacturing, statistical process control, and sustainable operations. Prerequisites: Senior standing in Mechanical Engineering or Engineering Management.

ME 170. Mechanical Design I. 0 or 4 Credits.
Advanced mechanics of materials, stress strain, bending and torsion of slender members, energy methods, finite element modeling, and CAD topics including parametric and solid modeling. Prerequisite: ME 101.

ME 171. Design of Elements. 3 Credits.
Mechanical fatigue criteria, fatigue analysis and design of springs, bolted/welded joints, gearing, shafts, bearings, power transmission. Computer-aided design and analysis. Prerequisite: Junior standing; ME 014.

ME 172. Design of Systems. 3 Credits.
Design synthesis and optimization; probabilistic aspects in design, expert systems in design. Prerequisite: ME 171.

ME 174. Industrial Design Project. 1 Credit.
Design projects from industry. Prerequisite: ME 171.
ME 185. Capstone Design I. 3 Credits.
Design teams apply their knowledge and skills, mentored by faculty and/or industry partners, to design, analyze, build, and test novel devices, mathematical models, or processes that meet functional needs. Prerequisite: Senior standing.

ME 186. Capstone Design II. 2 Credits.
Design teams apply their knowledge and skills, mentored by faculty and/or industry partners, to design and build novel devices that meet functional needs. Prerequisite: ME 185.

ME 191. Senior Thesis. 3 Credits.
Investigation of a research or design project under supervision of assigned staff member culminating in acceptable thesis. Prerequisite: Senior standing; department permission.

ME 193. College Honors. 1-3 Credits.
ME 194. College Honors. 1-6 Credits.
ME 195. Intermediate Special Topics. 1-18 Credits.
See Schedule of Courses for specific titles. Prerequisite: Senior standing in Civil or Mechanical Engineering.

ME 203. Machinery Analysis & Synthesis. 3 Credits.
Kinematic and kinetic analysis of two- and three-dimensional machines; kinematic synthesis, electromechanical and servo mechanisms; application to robotic mechanisms. Prerequisite: Senior standing in ME.

ME 207. Bioengineering. 3 Credits.
Introduction to bioengineering including biomechanics, rehabilitation, instrumentation, imaging, biomaterials, and transport. Pre/co-requisites: Senior/Graduate standing in Engineering; Instructor permission.

ME 208. Biomechanics: Tissue Engr. 3 Credits.
Solid biomechanics including structure, function and mechanical properties of biological tissues. Tissue engineering involving cell mechanics, scaffold materials, and signaling. Current literature topics are covered. Pre/co-requisites: Senior/Graduate standing in Engineering; Instructor permission.

ME 209. Biomechanics: Transport Proc. 3 Credits.
Transport and kinetic processes to vascular biology, respiratory mechanics and medicine. Steady and unsteady laminar flow, pulse wave reflections, curved and collapsible tube flow, turbulence. Pre/co-requisites: Senior/Graduate standing in Engineering; Instructor permission.

ME 210. Control Systems. 3 Credits.
Analysis and design of continuous and discrete-time control systems; stability, signal flow, performance criteria, classical and state variable methods, simulation design tools, computer-based realizations. Prerequisites: EE 171 or ME 111. Cross-listed with: EE 210.

ME 218. Numerical Methods for Engineer. 3 Credits.
Foundational concepts of numerical integration, numerical differentiation, and numerical approximation and solution of differential and partial differential equations of the type encountered in the analysis of engineering problems and data processing. Prerequisites: MATH 271, CS 020, MATH 124.

ME 230. Orbital Mechanics. 3 Credits.
Motion of spacecraft in a central gravitational field. Two and restricted three-body problems; Kepler’s equation; orbital maneuvers and rendezvous; interplanetary and lunar trajectories. Prerequisite: ME 012. Co-requisites: ME 111 or Instructor permission.

ME 233. Vortex Flows. 3 Credits.
General theorems of vorticity transport in fluids; methods for solution of vortex flows; application to wake vortices, turbulent wall-layer vortices, wing-tip vortices, intake vortices, vortex-structure interaction, vortex reconnection, vortex breakdown, tornadoes and hurricanes. Prerequisite: ME 143.

ME 234. Mechanical Vibrations. 3 Credits.
Analysis, measurement, and control of mechanical vibrations; SDOF, MDOF, and rotating systems, forced, free, and random vibrations. Prerequisite: ME 111 or Senior/Graduate standing in engineering or physical sciences.

ME 235. Turbomach Vibration Anly/Tstng. 2 Credits.
Vibration in rotating machines; vibration measurement techniques; machinery condition and degradation; condition monitoring and predictive maintenance; industrial vibration techniques including proximity probes, accelerometers, FFT analyzer. Prerequisite: ME 244.

ME 237. Turbulence. 3 Credits.
Description of turbulent flows; statistical and modeling of turbulent flows; Navier Stokes as a dynamical system; experimental and numerical approaches. Prerequisite: ME 143.

ME 238. Energy Systems Engineering. 3 Credits.
Engineering assessment of both potentially sustainable and unsustainable practical primary energy systems. Examination of options of meeting demand and impacts on the environment. Prerequisite: ME 042.

ME 239. Rocket Propulsion. 3 Credits.
Flight mechanics and propulsion requirements for atmospheric and space flight. Thermochemistry of fuels and propellants. Operating principles of chemical, electrical and nuclear propulsion systems. Pre/co-requisites: ME 143/ME 240 recommended or permission of the Instructor.

ME 240. Compressible Flow. 3 Credits.
Theory of compressible flow. Normal and oblique shocks; expansion waves; unsteady wave motion; method of characteristics; linearized external flows; conical and 3D flows. Prerequisite: ME 143 or equivalent.
ME 241. Combustion Processes. 3 Credits.
Combustion thermodynamics; chemical kinetics; laminar flames, premixed and diffusion; turbulent flames; ignition, explosion, and detonation; droplet combustion; flame spread; large scale fires; rocket combustion. Prerequisite: Senior/Graduate standing.

ME 242. Adv Engr Thermodynamics I. 3 Credits.
Foundations of statistical mechanics. Gases and crystals. Chemical equilibrium. Irreversible processes. Prerequisite: Senior/Graduate standing or permission.

ME 243. Incompressible Flow. 3 Credits.
Intermediate treatment of incompressible fluid flow; Navier- Stokes equations; two-dimensional potential flows; wing theory; vorticity and vortex structures; laminar and turbulent boundary layers. Prerequisites: ME 143 or equivalent.

ME 244. Intro to Turbomachinery Anyl. 2 Credits.
Fundamental turbomachinery principles of fluid mechanics, thermodynamics, and structural analysis; basic equations and computational techniques for analysis and design to model and evaluate turbomachinery. Prerequisite: ME 243, MATH 271.

ME 245. Advanced Heat Transfer I. 3 Credits.
Analytical methods for multidimensional steady and transient heat conduction; phase change and moving boundaries. Thermal radiation exchange in enclosures; view factors; emitting/absorbing gases. Prerequisites: ME 144 or equivalent, or by Instructor permission.

ME 246. Centrifugal Compressors. 2 Credits.
Fluid dynamic and thermodynamic principles of centrifugal compressor design and design practice; limits of stable operation and instability prediction and control. Prerequisite: ME 244.

ME 247. Centrifugal Pumps. 2 Credits.
Centrifugal pump design principles and practice; performance limits; cavitation; design tools and pump design optimization. Prerequisite: ME 244.

ME 248. Turbomachinery Special Topics. 1 or 2 Credit.
Content in axial fans/compressors; axial, radial, or steam turbines; CFD, dynamics/rotordynamics, or materials for turbo-machinery; power plant or refrigeration cycle developments; turbocharged and compound IC-engines. Prerequisite: ME 244.

ME 249. Computational Fluids Engr. 0 or 3 Credits.
Computational methods for solving the Navier-Stokes equations and combined thermo-fluid flows; finite- differences and finite-volume techniques; use of standard commercial CFD software. Prerequisite: ME 143 or equivalent.

ME 252. Mechanical Behavior Materials. 3 Credits.
Isotropic and anisotropic elasticity; theory of plasticity; deformation mechanisms in crystalline solids; dislocation theory; creep behavior; advanced fatigue and fracture mechanisms. Prerequisites: ME 101; Instructor permission.

ME 253. Corrosion of Materials. 3 Credits.

ME 255. Adv Engineering Materials. 3 Credits.
Advanced material processing; physical and mechanical principles of high-temperature alloys, light-weight materials, thin films, nanomaterials, and biomedical materials; elements of computational materials design. Prerequisites: Senior/Graduate standing; or Instructor permission.

ME 257. Composite Materials. 3 Credits.

ME 259. Computational Solid Mechanics. 3 Credits.
Computational methods using the finite element analysis (FEA) applied to linear elastic and non-linear problems in the mechanics of deformable solids and structures, contact mechanics, and fracture mechanics. Hands-on computational experience using a commercial FEA software. Prerequisites: ME 014, MATH 124, and MATH 271, or equivalent.

ME 265. Integrated Product Developmnt. 3 Credits.
Project- based course focusing on the entire product life cycle. Team dynamics, process and product design, quality, materials, management, and environmentally-conscious manufacturing. Prerequisite: Senior standing. Cross-listed with: BSAD 293.

ME 270. Structural Dynamics. 3 Credits.
Vibrations, matrices, earthquake engineering stability and wave propagation. Prerequisites: Senior/Graduate standing in Engineering or physical sciences, or Instructor permission. Cross-listed with: CE 272.

ME 271. Micro and Nano Systems. 3 Credits.
Operating principles, fabrication and design of engineered systems with submillimeter dimensions. Prerequisites: Senior/Graduate standing in Engineering or physical sciences.

ME 281. Seminar. 1 Credit.
Presentation and discussion of advanced mechanical engineering problems and current developments. Prerequisite: Senior/Graduate engineering enrollment.

ME 282. Seminar. 1 Credit.
Presentation and discussion of advanced mechanical engineering problems and current developments. Prerequisite: Senior/Graduate engineering enrollment.

ME 283. Lab Techniques Turbomach Dev. 2 Credits.
Instruments and transducers for performance, flow, and structural measurements in turbo-machinery; the role of test data in design and development; experimental data acquisition and processing. Prerequisite: ME 244.
ME 285. Biomedical Engineering Seminar. 1 Credit.
Presentation and discussion of advanced biomedical engineering problems and current research developments. Prerequisite: Senior/Graduate engineering enrollment.

ME 295. Advanced Special Topics. 1-18 Credits.
Content is dictated by expanding professional interest in newly developing, or recently developed, technical areas in which there is particular need or opportunity. Prerequisite: Senior/Graduate standing.