Department of Mechanical Engineering

Chairperson: Ghali, Kamel
Professors: Darwish, Marwan; Ghali, Kamel; Ghaddar, Nesreen; Hamade, Ramsey; Moukalled, Fadl; Shihadeh, Alan
Professor Emeritus: Sakkal, Fateh
Associate Professors: Asmar, Daniel; Kuran, Albert; Lakdis, Issam; Liermann, Matthias; Oweis, Ghanem; Shehadeh, Mutaseem
Assistant Professors: Daher, Naseem; Harb, Mohammad; Shammas, Elie; Samir, Mustapha
Lecturers: Kasamany, Jihad; Najm, Wajih
Instructors: Allouche, Mohamad; Al Saidi, Abdul-Kader; Babikian, Sevag; Balhas, Zainab; Haddad, Marwan; Karaogklanian, Nareg; Kassis, Lina; Kfoury, Elie; Seif, Charbel

The Department of Mechanical Engineering offers one undergraduate degree program that leads to a Bachelor of Engineering with a major in Mechanical Engineering (BE in ME) and a minor in Applied Energy.

Bachelor of Engineering (BE)
Major: Mechanical Engineering

The Mechanical Engineering Program extends over a four-year period offered exclusively on a daytime, on-campus basis. The program is offered in 11 terms whereby eight terms are 16-week Fall/Spring semesters given over four years, and three terms are eight-week summer terms taken during the first three years of the program. In the summer term of the third year (Term IX), students are required to participate in a practical training program with a local, regional, or international organization. The entire program is equivalent to five academic years but is completed in four calendar years with three summer terms.

The undergraduate program also provides the students with options to pursue minors in the following:

- Applied Energy Minor
- Other minors offered by the Maroun Semaan Faculty of Engineering and Architecture, Faculty of Arts and Sciences, and the Suliman S. Olayan School of Business
Program Mission

The mechanical engineering faculty has agreed that the undergraduate program mission is as follows:

The undergraduate program in Mechanical Engineering seeks to empower students to pursue successful careers and to create a learning environment in which they can develop their creative and critical thinking, their ability to grow into lifelong learners in the light of ever-increasing challenges of modern technology, and their commitment to the ethical and professional responsibilities required in their calling at the global level while focusing on the needs of Lebanon and the region.

Program Educational Objectives

The program is based on the following educational objectives that were approved by the mechanical engineering faculty members on May 27, 2010:

Our graduates will be able to advance successfully in their careers as reflected in continued employment, job satisfaction, leadership responsibilities, and professional recognition.

Our graduates will be able to succeed in graduate studies as reflected in admission to highly ranked programs, timely completion of degree requirements, and recognition by competitive fellowships and other awards.

Program Requirements

The undergraduate curriculum for the degree of Bachelor of Engineering (BE), major: Mechanical Engineering is a five-year program. It consists of 173 semester credit hours of course work of which 30 credits are completed in the freshman year while the student is enrolled in the Faculty of Arts and Sciences and 143 credits are completed in four years while the student is enrolled in the Maroun Semaan Faculty of Engineering and Architecture. Students admitted at the sophomore level will be required to complete 143 credits in four years to earn the degree as outlined here:

• **General Engineering:** FEAA 200, CIVE 210, EECE 210, EECE 231, EECE 312, EECE 312L, INDE 301

• **Mathematics:** MATH 201, MATH 202, MATH 212, MATH 218, MATH 251, STAT 230

• **Sciences:** PHYS 211, PHYS 211L, CHEM 202, and one biology elective (BIOL 201 level or above, except BIOL 209)

• **General Education:** Arabic course (based on APT), ENGL 206, one English elective (BIOL 201 level or above, except BIOL 209), and one course on ethics approved for the GE program

• **ME Core Courses:** MECH 201, MECH 230, MECH 310, MECH 314, MECH 320, MECH 332, MECH 340, MECH 341, MECH 410L, MECH 412, MECH 414, MECH 420, MECH 421, MECH 430, MECH 432, MECH 436, MECH 510, and MECH 520

• **Technical Electives:** Five courses with at least two from the selected ME track. One elective (a science senior level course) can be from outside the major

• **Approved Experience:** MECH 500

• **Final Year Project:** MECH 501 and MECH 502

Curriculum

<table>
<thead>
<tr>
<th>Term I (Fall)</th>
<th>Credits</th>
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<tbody>
<tr>
<td>MATH 201</td>
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<td>CIVE 210</td>
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<td>PHYS 211</td>
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<tr>
<td>EECE 210</td>
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<tr>
<td>STAT 230</td>
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<td>CHEM 202</td>
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<td>English Elective</td>
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<tr>
<td>EECE 312</td>
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<td>MATH 212</td>
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<td>MECH 310</td>
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<td>MECH 340</td>
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<td>Humanities Elective</td>
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<th>Term V (Spring)</th>
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<td>MATH 218</td>
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<td>MECH 314</td>
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<td>MECH 320</td>
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<td>MECH 332</td>
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<td>MECH 341</td>
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<td>MECH 430</td>
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<tr>
<td>MECH 432</td>
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<td>Arabic Elective</td>
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<td><strong>Total 8</strong></td>
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### Mechanical Engineering Optional Tracks

The core courses in the Mechanical Engineering Program are offered in the following track areas:

- Thermal and Fluid Engineering
- Mechatronics
- Design, Materials, and Manufacturing

The student may opt for any track (Thermal and Fluid Engineering, Mechatronics, or Design, Materials, and Manufacturing) by taking at least three technical electives in the selected track. Normally one technical elective is allowed from outside the mechanical engineering major.

The ME Focus area in Control and Robotics provides a coherent academic framework between the ECE and ME departments in the areas of control, instrumentation, and robotics. This track is open to all undergraduate ME and ECE students.

#### Track I: Thermal and Fluid Engineering Credits

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
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<tbody>
<tr>
<td>MECH 310 Thermodynamics I</td>
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<tr>
<td>MECH 414 Thermodynamics II</td>
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<tr>
<td>MECH 410L Thermal/Fluid Systems Laboratory</td>
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<tr>
<td>MECH 412 Heat Transfer</td>
<td>3</td>
</tr>
<tr>
<td>MECH 501 Final Year Project I</td>
<td>1</td>
</tr>
<tr>
<td>MECH 502 Final Year Project II</td>
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<tr>
<td>MECH 510 Design of Thermal Systems</td>
<td>3</td>
</tr>
<tr>
<td>MECH 511 Intermediate Fluid Mechanics</td>
<td>3</td>
</tr>
<tr>
<td>MECH 512 Internal Combustion Engines</td>
<td>3</td>
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<tr>
<td>MECH 513 Air Conditioning</td>
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<tr>
<td>MECH 514 Gas Turbines</td>
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<td>MECH 515 Steam Turbines</td>
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<tr>
<td>MECH 516 Aerodynamics</td>
<td>3</td>
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<tr>
<td>MECH 603 Solar Energy</td>
<td>3</td>
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<tr>
<td>MECH 604 Refrigeration</td>
<td>3</td>
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<tr>
<td>MECH 606 Aerosol Dynamics</td>
<td>3</td>
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<tr>
<td>MECH 607 Microflows Fundamentals and Applications</td>
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#### Track II: Design, Materials, and Manufacturing Credits

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
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<tr>
<td>CIVE 210 Statics</td>
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<tr>
<td>MECH 201 Computer Aided Drawing and Design (CADD)</td>
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</tr>
<tr>
<td>MECH 320 Mechanics of Materials</td>
<td>3</td>
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<tr>
<td>MECH 332 Mechanics of Machines</td>
<td>3</td>
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<tr>
<td>MECH 340 Engineering Materials</td>
<td>3</td>
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<tr>
<td>MECH 341L Materials Lab</td>
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<tr>
<td>MECH 420 Mechanical Design I</td>
<td>3</td>
</tr>
<tr>
<td>MECH 421 Manufacturing Processes I</td>
<td>3</td>
</tr>
<tr>
<td>MECH 422 Manufacturing Processes II</td>
<td>3</td>
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</table>
ME Focus Area in Control and Robotics

Students choosing to enroll in the Control and Robotics Focus (CRF) area should satisfy the following course requirements:

- Two core courses and one laboratory in their respective departments (listed in the table below)

### Core Courses

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
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<tbody>
<tr>
<td>MECH 430</td>
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<tr>
<td>MECH 432</td>
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<tr>
<td>MECH 436</td>
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</table>

- Three elective courses from either department (ECE/ME) (listed in the tables below) provided they obtain the necessary prerequisites for any given course. At least one course from each of lists A (control theory) and B (robotics) must be chosen, and one elective from either list A, B, or C.

### Technical Elective Courses (List A Control)

<table>
<thead>
<tr>
<th>Course</th>
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<tbody>
<tr>
<td>MECH 648/EECE 669</td>
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<tr>
<td>MECH 653/EECE 660</td>
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<tr>
<td>MECH 655/EECE 662</td>
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<tr>
<td>MECH 656/EECE 697</td>
<td>3</td>
</tr>
<tr>
<td>MECH 650/EECE 698</td>
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### Technical Elective Courses (List B Robotics)

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
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<tbody>
<tr>
<td>MECH 530/EECE 530</td>
<td>3</td>
</tr>
<tr>
<td>MECH 641/EECE 661</td>
<td>3</td>
</tr>
<tr>
<td>MECH 646/EECE 697</td>
<td>3</td>
</tr>
<tr>
<td>MECH 650/EECE 698</td>
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</table>

### Technical Elective Courses (List C)

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
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<tbody>
<tr>
<td>MECH 655/EECE 463</td>
<td>3</td>
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<tr>
<td>MECH 642/EECE 692</td>
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</tr>
<tr>
<td>MECH 647/EECE 699</td>
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### Minor in Applied Energy

The minor in Applied Energy is open to all SFEA students who are interested in the energy domain and in renewable energy applications. Students seeking professional careers that will focus on energy, the environment, sustainable applications in buildings, and energy systems may find this minor attractive. The minor in applied energy is administered by the Department of Mechanical Engineering.
Applied Energy Minor Program Structure

A student wishing to complete the minor is required to complete a minimum of 18 credits: 6 credits from the list of core courses and 12 credits from the list of elective courses.

The first component is a number of core courses (6 credits) that provide a foundation for the understanding of energy science and technology and its economy. The second component is a number of elective courses (12 credits), selected by the student in close consultation with academic advisor for the applied energy minor.

Required Courses (6 credits)

- ECON 333 Energy Economics and Policy 3 cr.

Elective Courses (Minimum of 12 credits)

CHEN 417 Reactor Engineering and Reactor Design 3 cr.
CHEN 470 Chemical Process Design 3 cr.
CHEN 471 Chemical Product Design 3 cr.
CHEN 541 biochemical and Bioprocess engineering 3 cr.
CHEN 570 Process Synthesis and Optimization 3 cr.
CHEN 612 Desalination 3 cr.
EECE 670 Power System Planning 3 cr.
EECE 671 Environmental Aspects of Energy Systems 3 cr.
EECE 672 Energy Planning and Policy 3 cr.
EECE 675 Renewable Energy Systems 3 cr.
ENST 320 Energy Laws and Case Studies 3 cr.
MECH 513 Air Conditioning 3 cr.
MECH 603 Solar Energy 3 cr.
MECH 631 Micro-electro mechanical Systems 3 cr.
MECH 670 Laboratory for Renewable Energy In Buildings 3 cr.
MECH 672 Modeling Energy Systems 3 cr.
MECH 673 Energy Efficient Building with Good Indoor Air Quality 3 cr.
MECH 676 Passive Building Design 3 cr.
MECH 677 Heat Pumps 3 cr.
MECH 679 Energy Audit Lab 3 cr.
MECH 681 Green Building Basics and LEED Practices

Other courses can be considered as part of the minor upon recommendation from the student advisor and approval of the Department Chair.

Course Descriptions

FEAA 200 Introduction to Engineering and Architecture 3 cr.
The course is designed to familiarize first year students with the different disciplines in Engineering and Architecture, including: Architecture, Civil, Mechanical, Electrical, Chemical, Industrial, and technologies used in the fields. The course takes a unique interdisciplinary approach to the field, and introduces the related disciplines in the world of engineering and architecture. The project is to promote interdisciplinary interaction and innovative thinking. The course is organized into modules covering the different disciplines within the Maroun Semaan Faculty of Engineering and Architecture. The last module showcases interdisciplinary projects demonstrating interactions among the different fields. The lectures explain as applicable to each discipline, through examples, notions of problem solving, design thinking, process of invention and innovation, environmental and civic responsibility, and measures of success in aesthetics and performance. The course project is a key component of the course. It has an interdisciplinary nature bringing ideas and solutions from all disciplines in engineering and architecture. Annually.

MECH 201 Computer Aided Drawing and Design (CADD) 1 cr.
The course aims at preparing the future engineer to be able to understand and create technical drawings. The course seeks to develop effective utilization of computer-aided drafting (CAD) skills in order to create engineering drawings: orthogonal projection, exploded and auxiliary views, sectioning and dimensionalizing, drafting formats. Part geometric construction, Assemblies and exploded assemblies. Parts and assemblies working Drawings. Engineering symbols. CADD project.

MECH 220 Engineering Graphics 3 cr.
The course aims at preparing the future engineer to be able to understand and create technical drawings. The course seeks to develop effective utilization of computer-aided drafting (CAD) skills in order to create engineering drawings: orthogonal projection, exploded and auxiliary views, sectioning and sectional views, dimensioning and tolerance schemes, standard drafting formats, and detailing. Introduction to the use of CAD packages (AutoCAD).

MECH 230 Dynamics 3 cr.
This is a basic course in engineering mechanics covering dynamics of particles and planar rigid bodies. This course introduces Newton's law of motion, the principle of work and energy, and the principle of impulse and momentum. Diagrammatic representations of the basic laws are applied on motion of particles, systems of particles, and rigid bodies. Prerequisites: CIVE 210 and MATH 201.

MECH 310 Thermodynamics I 3 cr.
This course seeks to provide a methodology by which students view objects in the physical universe as “systems” and apply to them the basic laws of conservation of mass, energy, and the entropy balance. The course covers the thermodynamic state and properties of a pure substance, energy and mass conservation, entropy and the second law. Applications involve closed setups and flow devices. Simple vapor and gas cycles applications.
MECH 314/ Introduction to Fluids Engineering 3 cr.
An introductory course on fluid behavior emphasizing conservation of mass, momentum, energy and dimensional analysis; study of fluid motion in terms of the velocity field, fluid acceleration, the pressure field, and the viscous effects; applications of Bernoulli's equation, Navier-Stokes, and modeling; flow in ducts, potential flows, and boundary layer flows. Prerequisite: MECH 310.

MECH 320 Mechanics of Materials 3 cr.
A course that addresses the mechanical behavior of materials under different loadings such as; axial, bending, transverse shear, torsion, and combined loadings. Stress and strain transformation is discussed. Deflection of beams and buckling in columns are covered. Prerequisites: MECH 201 and CIVE 210.

MECH 332 Mechanics of Machines 3 cr.
A course that deals with the mechanization of motion, kinematics analysis of linkage mechanisms, synthesis of cam-follower mechanisms, gear terminology and types of gears, analysis and synthesis of gear trains, force analysis, and introduction to linkage synthesis. Prerequisite: MECH 230.

MECH 340 Engineering Materials 3 cr.
The course introduces fundamental concepts in materials science as applied to engineering materials: crystalline structures; imperfections, dislocations, and strengthening mechanisms; diffusion; phase diagrams and transformations; ferrous and non-ferrous metal alloys, ceramics, and polymers; structure-property relationships; material selection case studies.

MECH 341 Materials Lab 1 cr.
The course seeks to accompany and compliment MECH 340: Engineering Materials. The laboratory sessions are designed to impart a qualitative and quantitative understanding of the mechanical properties of engineering materials. The laboratory sessions will also examine topics related to the microstructure of materials. Corequisite: MECH 340.

MECH 410L Thermal/Fluid Systems Laboratory 1 cr.
A series of experiments on basic thermodynamic cycles, psychrometry, combustion, and elementary fluid mechanics, with special emphasis on the use of the computer as a laboratory tool for data acquisition, reduction, analysis, and report preparation. Prerequisite: MECH 310.

MECH 412 Heat Transfer 3 cr.
The course seeks to impart an understanding of the fundamental concepts and laws of conduction, convection and radiation heat transfer and their application to the solution of engineering thermal problems. The course covers steady and transient heat conduction; extended surfaces; numerical simulations of conduction in one and two-dimensional problems; external and internal forced convection of laminar and turbulent flows; natural convection; heat exchanger principles; and thermal radiation, view factors and radiation exchange between diffuse and gray surfaces. The use of Matlab is integrated into the homework assignments. Prerequisite: MECH 314.

MECH 414 Thermodynamics II 3 cr.
A course investigating the availability and work potential of systems; irreversibility; second law efficiency; availability; gas mixtures; air-conditioning; chemical reactions; high speed flow, nozzles and diffusers; environmental, economic, and social implications. Prerequisite: MECH 310.

MECH 420 Mechanical Design I 3 cr.
This is an introductory course in course design in which one learns how to determine the structural integrity of common machine components and to apply this knowledge within the context of machine design problems. Mechanical elements such as shafts, bearings, springs, welding joints and fasteners are studied with emphasis on their behavior under both static and fatigue loading. Prerequisites: MECH 320 and MECH 340.

MECH 421 Manufacturing Processes I 3 cr.
A course covering traditional material removal processes (machining and abrasion), CNC machining, as well as non-traditional material removal processes (EDM, ECM, thermal cutting, etc.); the science behind these technologies; assembly processes such as welding, brazing, soldering, and fastening are also covered. The course emphasizes process capabilities and limitations, relative cost, and guidelines for process selection; and design for manufacturing guidelines. This course contains hands-on exercises in a machine shop environment. Prerequisites: MECH 320 and MECH 340.

MECH 430 Process Instrumentation and Measurements 3 cr.
A course on general concepts of measurement systems; classification of sensors and sensor types; interfacing concepts; data acquisition, manipulation, transmission, and recording; introduction to LABVIEW; applications; team project on design, and implementation of a measuring device. Prerequisites: PHYS 211 and EECE 312.

MECH 432 Dynamic System Analysis 2 cr.
A course introducing dynamic modeling and analysis of mechanical, electrical, thermal, and fluid systems. The course integrates software to test and analyze the modeled systems. Prerequisites: EECE 210 and CIVE 210.

MECH 436 Control Systems 3 cr.
This course and lab teach the fundamentals of designing feedback control systems. As a prerequisite the student has taken an introductory course on modeling and (linear) analysis of dynamic systems (for example MECH 432). This course consists of a theory focused classroom and application oriented weekly labs. Both components are graded separately and students have to pass both, in order to pass the course. The theory-focused lecture component familiarizes students with tools to analyze the performance of closed loop control systems and to alter their dynamics according to requirement specifications. As an outcome, the student is able to choose appropriate control strategies from a repertoire of linear control concepts and can execute their appropriate design. The lecture course grade is 68% of the total grade. An application oriented lab is conducted in conjunction with the course, where the use of Matlab/Simulink for the analysis and design of control systems is practiced. Students have the opportunity to apply course concepts on practical examples and to conduct control experiments on hardware setups. Labview is used to interface with the hardware setups. The lab grade is 32% of the total grade. Students working in groups of three will develop a project in the second half of the semester. Prerequisites: EECE 210, MECH 430 and MECH 432.
MECH 499  Undergraduate Research  3 cr.
This course provides undergraduate students with advanced standing the opportunity to participate in faculty-supervised research. Before registering, students must submit a proposal for approval by the supervising faculty member and the department; the proposal must describe the nature of the research, specific goals, and deliverables at the end of the semester. The course may be counted once, as a technical elective. Prerequisites: Completion of 65 required credits in the major and a cumulative average of 80 or above.

MECH 500  Approved Experience  1 b.
This is an eight-week professional training course in mechanical engineering.

MECH 501  Final Year Project I  1 cr.
The aim of this course is to provide students with practical experience in some design aspects of mechanical engineering. Students, working in groups, write a literature survey of an assigned project, critically analyze its components, and develop a bill of material necessary for the completion of the project. Prerequisites: MECH 400, MECH 420, and MATH 251.

MECH 502  Final Year Project II  4 cr.
A course in which the student integrates his/her acquired knowledge to deliver the product researched and planned in MECH 501. Prerequisite: MECH 501.

MECH 503  Special Topics in Mechanical Engineering  3 cr.
The course seeks to develop in students the ability to integrate rate mechanisms (i.e., heat transfer and fluid dynamics) into thermodynamic system modeling, and it analyses and provides the nature of the research, specific goals, and deliverables at the end of the semester. The course may be counted once, as a technical elective.

MECH 504  Final Year Project III  2 cr.
This is an eight-week professional training course in mechanical engineering.

MECH 505  Final Year Project IV  2 cr.
A course in which the student integrates his/her acquired knowledge to deliver the product researched and planned in MECH 501. Prerequisite: MECH 501.

MECH 510  Design of Thermal Systems  3 cr.
The course seeks to develop in students the ability to integrate rate mechanisms (i.e., heat transfer and fluid dynamics) into thermodynamic system modeling, and it analyses and provides the nature of the research, specific goals, and deliverables at the end of the semester. The course may be counted once, as a technical elective.

MECH 511  Intermediate Fluid Mechanics  3 cr.
A course that deals with potential flow and boundary layer analysis; lift and drag; flow separation; the use of computational techniques to solve boundary-layer problems; viscous internal channel flow and lubrication theory; one-dimensional compressible flow in nozzles and ducts; normal shock waves and channel flow with friction or heat transfer; fluid machinery including pumps and hydraulic turbines. Prerequisites: MECH 410L, MECH 412 and MATH 251.

MECH 512  Internal Combustion Engines  3 cr.
A course that examines the fundamentals of internal combustion engine design and operation, with emphasis on fluid/thermal processes. Topics include analysis of the respiration, combustion, and pollutant formation processes; heat transfer and friction phenomena; engine types and performance parameters; thermo-chemistry of fuel-air mixtures; the use of engine cycle models for performance predictions; and social implications of motorization. Prereq: or corequisites: CHEM 202, MECH 414, and MECH 430.

MECH 513  Air Conditioning  3 cr.
A course on human thermal comfort and indoor air quality; solar radiation; heating and cooling load calculations in buildings; air conditioning systems; air and water distribution systems; computer-based calculations. Prerequisite: MECH 412.

MECH 514  Gas Turbines  3 cr.
A course that introduces the thermodynamic and aerodynamic theory forming the basis of gas turbine design: shaft power cycles; gas turbine cycles for aircraft propulsion; turbofan and turbojet engines; design and analysis of centrifugal and axial flow compressors and turbines. Prerequisites: MECH 314 and MECH 414.

MECH 515  Steam Turbines  3 cr.
A course that deals with impulse and reaction steam turbines, steam turbine cycles, flow of steam in nozzles, design aspects of turbines stage losses and efficiency, velocity diagrams; impulse and reaction blading velocities; nucleation, condensation, and two-phase phenomena in flowing steam; boiler room and its various equipment; the complete steam power plant; governors, electric generator, and power transmission lines. Pre- or corequisites: MECH 314 and MECH 414.

MECH 516  Aerodynamics  3 cr.
A course on theoretical and empirical methods for calculating the loads on airfoils and finite wings by application of classical potential theory, thin airfoil approximations, lifting line theory, and panel methods; wings and airplanes; application of linearized supersonic flow to supersonic airfoils; performance and constraint analysis; longitudinal stability and control. Pre- or corequisites: MECH 314 and MECH 414.

MECH 517  Hydraulic Turbines for Power Generation  3 cr.
This course presents the principles and development of hydraulic turbines with emphasis on the techniques for formulating and solving problems. The importance of the incoming flow direction will be stressed. The Pelton, or tangential flow, turbine will be studied in detail. The course will provide a brief introduction to cavitation. Prerequisites: MECH 310 and MECH 410.

MECH 518  Compressible Flows  3 cr.
The objective of the course is to impart an understanding of the fundamental principles of steady and unsteady one-dimensional perfect-gas flow. Students learn about the behavior of homogeneous and homentropic flow, develop an understanding of normal shock waves and highly supersonic flow in nozzles; learn how to analyze frictional homogeneous flow in a constant-area duct and frictionless diabatic flow in a constant-area duct; and learn how to draw skeleton wave diagrams of wave processes. Prerequisites: MECH 310 and MECH 314.

MECH 520  Mechanical Design II  3 cr.
This is an advanced course in mechanical design. Students taking this course are expected to have a firm grasp in the fundamentals of failure theories. This course proposes the methods for designing and selecting components such as gears, belts, clutches, brakes, flywheels, and journal bearings. A design project using a finite element package is emphasized. Prerequisites: MECH 332 and MECH 420.
MECH 521  Manufacturing Processes II  3 cr.
A course on heat treatments, deformation, phase-change, and particulate consolidation processing of metals; fabrication processing of non-metallic engineering materials such as ceramics, polymers, and composites; emphasis on process capabilities and limitations, relative cost, and guidelines for process selection; the behavior of materials under processing conditions; design for manufacturing guidelines. This course emphasizes hands-on training exercises. Prerequisite: MECH 340.

MECH 522  Mechanical CAD/CAE/CAM  3 cr.
The course gives students exposure to the realm of computer-aided design (CAD), computer-aided engineering (CAE), and computer-aided manufacturing (CAM). The course teaches the students to harness the power of these powerful tools in the solution of various problems of mechanical engineering. The course utilizes several commercially available software packages but the emphasis is placed on Pro/Engineer. Prerequisites: MECH 320, MECH 420, and MECH 432.

MECH 530/ ECEE 560  Mechatronics System Design  3 cr.
A course that discusses mechatronics; data; numbering systems, architecture of the 8-bit Motorola MC68HC11 microcontroller, assembly language programming, A/D and D/A conversion; parallel I/O programmable timer operation, interfacing sensors and actuators, applications; a team project on design and implementation of a mechatronic system. Prerequisites: ECEE 312, MECH 430 or ECEE 461.

MECH 531  Mechanical Vibrations  3 cr.
A course on free and forced response of non-damped and damped systems; damping vibration absorption; response of discrete multi-degree of freedom systems; modal analysis; vibration measurement, case studies, vibration analysis with Matlab and Simulink. Prerequisite: MECH 230.

MECH 532  Dynamics and Applications  3 cr.
This course examines the dynamics of particles and rigid bodies moving in three dimensions. Topics include Lagrange’s equations of motion for particles, rotations of rigid bodies, Euler angles and parameters, kinematics of rigid bodies, and the Newton-Euler equations of motion for rigid bodies. The course material will be illustrated with real examples such as gyroscopes, spinning tops, vehicles, and satellites. Applications of the material range from vehicle navigation to celestial mechanics, numerical simulations, and animations. Prerequisite: MECH 230.

MECH 533  Electric Machines and Drives  3 cr.
This course covers the fundamentals of electromagnetic circuits, three-phase circuits, transformers: single-phase ideal and real transformers, construction and operation; fundamentals of AC machines, operation of synchronous generators; induction motors: construction and principle of operation, power, torque, and efficiency expressions; AC drives: starting and speed control strategies, plugging and regenerative breaking; DC motors types and control strategies, stepper motors: types, operational characteristics, drivers configurations. Prerequisites: ECEE 210 and MECH 310.

MECH 535  Fluid Power Systems  3 cr.
This is a senior level undergraduate lecture course which covers the fundamentals of fluid power transmission and drive technology. Students learn about the main hydraulic and pneumatic components and their static and dynamic performance characteristics. Students learn how to read circuit diagrams and understand the principles of circuit operation. Through the use of simulation software students will learn to design and analyze complex fluid power systems. Prerequisites: MECH 314 and MECH 436.

MECH 540  Selection and Properties of Materials  3 cr.
A course that reviews the mechanical behavior of materials. Topics covered include structure-property relationships in materials; continuum mechanics and tensor notation; theorems of plastic, elastic, plastic, viscoelastic behavior of materials; elements of creep, fatigue, and fracture mechanics. Prerequisite: MECH 340.

MECH 550  Computer Applications in Mechanical Engineering  3 cr.
A course dealing with the application of numerical techniques for the solution of a variety of mechanical engineering problems involving systems of linear or nonlinear algebraic equations, systems of ordinary differential equations of the initial and boundary value types, systems of ordinary differential equations, and partial differential equations of the parabolic, elliptic, and hyperbolic types. Engineering applications are introduced through a number of case study problems. Prerequisites: MATH 202 and MATH 251.

MECH 555/ ECEE 463  Artificial Intelligence for Control Systems  3 cr.
This is an introductory course in the evolving field of artificial intelligence (AI) for control systems. It aims at giving students a solid foundation in AI by covering basic techniques such as A* searching, reasoning under uncertainty, probabilistic reasoning over time, multi objects tracking, path planning, scheduling, communicating, perceiving and learning as applied to control systems, robotics and manufacturing. The group project and individual lab assignments will provide students with hands on implementation experience of an intelligent control agent capable of basic learning. Prerequisite: ECEE 460 or MECH 436.

MECH 600  Applied Reservoir Engineering I  3 cr.
This course introduces the concepts and principles needed to understand and analyze hydrocarbon reservoir fluid systems, and defines (with the help of geological and petrophysical principles) the size and contents of petroleum accumulations. Students will learn to organize programs for systematically collecting, recording, and analyzing data describing fundamental characteristics of individual well and reservoir performance (i.e. pressure, production, PVT data). The course covers topics on: fundamental concepts of fluid distribution, porosity distribution, trapping conditions; nature and type of primary drive mechanisms; production rates, ultimate recoveries, and reserves of reservoirs; supplementary recovery schemes to augment and improve primary recovery; economics analysis of developing and producing reservoirs and conducting supplementary recovery operations. Prerequisites: MECH 314 or CIVE 340, and CHEN 490.
MECH 602  Energy Conservation and Utilization  3 cr.
A course that deals with methods for reduction of losses and gains from a building envelope, energy conservation in cooling, heating, air-handling, and plumbing systems, energy management program. Prerequisites: MECH 310 and MECH 412.

MECH 603  Solar Energy  3 cr.
A course discussing the fundamentals of solar radiation, collectors and concentrators, energy storage, estimation and conversion formulas for solar radiation. Prerequisite: MECH 412.

MECH 604  Refrigeration  3 cr.
A course on fundamental concepts and principles, cold storage; functions and specifications of refrigeration equipment, applications. Prerequisite: MECH 412.

MECH 606  Aerosol Dynamics  3 cr.
This course covers the physical and chemical principles that underlie the behavior of aerosols—collections of solid or liquid particles, such as clouds, smoke, and dust, suspended in gases—and the instruments used to measure them. Topics include: aerosol particle characterization; transport properties and phenomena in quiescent, laminar, and turbulent flows; gas- and particle-particle interactions; and applications to human respiratory tract deposition and atmospheric pollution. Prerequisites: MECH 314, MECH 412, and MECH 414; or consent of instructor.

MECH 607  Micro Flows Fundamentals and Applications  3 cr.
A course on the theory and applications of micro flows; the continuum hypothesis and the various flow regimes; shear and pressure driven micro flows; electrokinetically driven liquid micro flows; compressibility effects of the micro flow of gases; particulate flows in bio-applications; modeling techniques; hybrid continuum-molecular methods; reduced order modeling of micro flows in multi-physics micro flow applications; case studies in BioMEMS. Prerequisites: MECH 310, MECH 314, and MECH 412; or equivalent.

MECH 608  Applied Reservoir Engineering II  3 cr.
This course introduces the advance concepts and principles needed to analyze hydrocarbon reservoir fluid systems, and defines the size and contents of petroleum accumulation. Students will learn to organize programs for collecting, recording, and analyzing data describing the advanced characteristics of individual well and reservoir performance. This course of advanced reservoir engineering topics covers a variety of topics such as: fluid flow in a porous medium; fluid distribution, fluid displacement; fractional flow equation; Buckley-Leverett equation; pressure draw-down and pressure buildup analysis; in addition to the nature and type of primary, secondary and tertiary recovery, water influx and prediction of water-flood behavior, reservoir model simulation and history matching. Prerequisite: MECH 600.

MECH 609  Experimental Methods in Fluid Dynamics  3 cr.
This is a graduate level course to introduce students to experimental methods used to measure fluid flow quantities such as pressures, forces, and velocities. The course starts with an introduction to what and why we measure, uncertainty analysis and measurement error estimation. Some basic techniques for data reduction and data post-processing are introduced. The available fluid measurement methods are surveyed briefly, with selected applications.

MECH 615  Continuum Mechanics  3 cr.
The course offers a unified presentation of continuum mechanics such as fluids, elasticity, plasticity, and viscoelasticity. The general concepts and principles applicable to all continuous media are presented following by defining equations for a particular media. Topics include fundamentals of tensor calculus, stress, deformation and strain, general principles, constitutive equations for solids and fluids.

MECH 618  Enterprise Resource Planning (ERP) in Manufacturing Systems  3 cr.
This course will cover how today's industries can cope with the challenges induced by global competition. The course will address: challenges of today's industry, consequences of these challenges on product design and on the organizations; the role of the information systems, PLM, ERP, and APS; and practice of PLM and ERP systems on the SAP Business Suite and Business by Design solution.

MECH 619  Quality Control in Manufacturing Systems  3 cr.
The course covers the foundations of modern methods of quality control and improvement that may be applied to manufacturing industries. It aims to introduce students to the tools and techniques of quality used in industrial applications to apply the tools and techniques to develop solutions for industrial problems. Emphasis is on the application of quality management techniques to solve industrial case problems. The course emphasizes the philosophy and fundamentals of quality control, the statistics foundations of quality control, statistical process control, acceptance sampling, and product and process design. Prerequisites: STAT 230 and MECH 421.

MECH 622  Modeling of Machining Processes and Machines  3 cr.
This course covers the principles and technology of metal machining; mechanics of orthogonal and 3D metal cutting; static deformations, forced and self-excited vibrations and chatter; and design principles of metal cutting CNC machines. Prerequisite: MECH 421.

MECH 624  Mechanics of Composite Materials  3 cr.
A course on anisotropic elasticity and laminate theory, analysis of various members of composite materials, energy methods, failure theories, and micromechanics. Materials and fabrication processes are introduced. Prerequisites: MECH 320 or CIVE 310, and MECH 340; or equivalent.

MECH 625  Fatigue of Materials  3 cr.
A course that deals with high cycle fatigue; low cycle fatigue; S-N curves; notched members; fatigue crack growth; cycling loading; Manson-Coffin curves; damage estimation; creep and damping. Prerequisite: MECH 320 or CIVE 310.
MECH 626 Metals and their Properties 3 cr.
A course that investigates ferrous and non-ferrous alloys; industrial equilibrium diagrams; heat treatment of metals; surface properties of metals; plastic deformation of metals; elements of fracture mechanics; process-structure-properties relations. Prerequisite: MECH 340.

MECH 627 Polymers and their Properties 3 cr.
A course on chemistry and nomenclature, polymerization and synthesis, characterization techniques, physical properties of polymers, viscoelasticity and mechanical properties and applications. Prerequisite: MECH 346.

MECH 628 Design of Mechanisms 3 cr.
A course involving graphical and analytical synthesis of single- and multi-loop linkage mechanisms for motion, path, and function generation through 2-3-4- and 5-precision positions; optimum synthesis of linkage mechanisms; synthesis of cam-follower mechanisms; synthesis of gear trains. Prerequisite: MECH 332.

MECH 630 Finite Element Methods in Mechanical Engineering 3 cr.
A course on the classification of machine components; displacement-based formulation; line elements and their applications in design of mechanical systems; isoparametric formulation; plane stress, plane strain, axi-symmetric, and solid elements and their applications; modeling considerations and error analysis; introduction to Potential Energy and Galerkin approaches; and analysis of Field problems. Prerequisites: MECH 420 and MATH 251.

MECH 632 Structural Health Monitoring 3 cr.
The general concepts of structural health monitoring will be introduced. The commonly used techniques to provide continuous monitoring will be discussed (vibration and ultrasonic wave based methods). Further, determination of critical measurement types and location; data acquisition systems and instruments; design of measurement setup will be discussed. Handling data with advanced machine learning algorithm such as artificial Neural Networking and support vector machine will be introduced, further students will be introduced to the damage detection and condition assessment process. Prerequisite: MECH 320, MECH 430.

MECH 631 Micro Electro Mechanical Systems (MEMS) 3 cr.
A course that deals with materials for micro-sensors and micro-actuators, materials for micro-structures, microfabrication techniques and processes for micromachining, computer-aided design and development of MEMS, commercial MEMS structures and systems, packaging for MEMS, future trends, and includes a team project. Prerequisite: MECH 436.

MECH 633 Biomechanics 3 cr.
A course on study of the biomechanical principles underlying the kinetics and kinematics of normal and abnormal human motion. Emphasis is placed on the interaction between biomechanical and physiologic factors (bone, joint, connective tissue, and muscle physiology and structure) in skeleto-motor function and the application of such in testing and practice in rehabilitation. The course is designed for senior level undergraduate/graduate engineering students with no previous anatomy/physiology. Prerequisite: MECH 320 or CIVE 310, or consent of instructor.

MECH 634 Biomaterial and Medical Devices 3 cr.
A course that examines the structure-property relationships for biomaterials and the medical applications of biomaterials and devices. The first part of the course focuses on the main classes of biomaterials, metal, ceramic, polymeric, and composite implant materials, as well as their interactions with the human body (biocompatibility). The second part examines the various applications of biomaterials and devices in different tissue and organ systems such as orthopedic, cardiovascular, dermatology, and dental applications. Experts from the medical community will be invited to discuss the various applications. Prerequisite: MECH 340 or consent of instructor.

MECH 637 Micromechanics and Crystal Plasticity 3 cr.
This course covers the theoretical knowledge of the deformation process in single and polycrystalline solids with an emphasis on the role of dislocations and other types of defects on the overall mechanical properties of materials. Topics will include an introduction to crystallography, defects in crystals, fundamentals of dislocations, strengthening mechanisms, microstructures, and yielding. Prerequisites: MECH 340 and MECH 320.

MECH 641/EECE 661 Robotics 3 cr.
A course discussing concepts and subsystems; robot architecture; mechanics of robots; kinematics and kinetics; sensors and intelligence; actuators; trajectory planning of end effector motion; motion and force control of manipulators; robot languages. Prerequisite: MECH 436 or EECE 460.

MECH 642/EECE 692 Computer Vision 3 cr.
An introductory course on the problems and solutions of modern computer vision. Topics covered include image acquisition and quantization; image segmentation; geometric framework for vision: single view and two-views; camera calibration; stereo; motion and optical flow; recognition; pose estimation in perspective images. Prerequisites: MATH 202 and EECE 230.

MECH 643 Mechatronics and Intelligent Machine Engineering II 3 cr.
A course on sensors, sensor noise and sensor fusion; actuators; system models and automated computer simulation; information, perception, and cognition; planning and control; architectures, design, and development; a team project is included. Prerequisites: MECH 340 and MECH 530.

MECH 644 Modal Analysis 3 cr.
A course reviewing MDOF system vibrations, frequency response functions, damping, mobility measurement, curve fitting and modal parameter extraction, derivation of mathematical models, laboratory experiments, and projects are included. Prerequisite: MECH 531.

MECH 645 Noise and Vibration Control 3 cr.
A course on fundamental concepts in noise and vibration, passive and active damping strategies, damping materials, control methods; and applications. Prerequisites: MECH 230, MATH 212, and MECH 531.
MECH 663  Computational Fluid Dynamics  3 cr.
This course introduces the fundamentals of system identification as the basic mathematical tools to fit models into empirical input-output data. While rooted in control theory, applications extend to general time-series modeling and forecasting, such as stock prices, biological data and others. Topics covered include nonparametric identification methods: time and frequency response analysis; parametric identification methods: prediction error methods, least squares, linear unbiased estimation and maximum likelihood; Convergence, consistency and asymptotic distribution of estimates; properties and practical modeling issues: bias distribution, experiment design and model validation. Prerequisite: Senior or graduate standing, or consent of instructor.

MECH 646  Wheeled Mobile Robotics  3cr.
A course that provides an in-depth coverage of wheeled mobile robots. The material covers: nonholonomy and integrability of kinematic constraints; modeling; kinematics, dynamics and state-space representation; and nonlinear control strategies (open-loop and closed-loop). Five case studies are covered all-over the course: car-like, cart-like, omni- directional wheeled, mobile wheeled pendulums and bike-like robots. Prerequisite: Senior or graduate standing.

MECH 647  Hydraulic Servo Systems  3 cr.
A graduate lecture course which covers the fundamentals of modeling and control of hydraulic servo-systems. It provides theoretical background and practical techniques for the modeling, identification and control of hydraulic servo-systems, Classical and advanced control algorithms are discussed. The use of Matlab/Simulink and DYMOLA will be an integral part in this course. Prerequisites: MECH 314 and MECH 436, or MECH 314 and EECE 460.

MECH 648  Nonlinear Systems: Analysis, Stability, and Control  3 cr.
This course presents a comprehensive exposition of the theory of nonlinear dynamical systems and its control with particular emphasis on techniques applicable to mechanical systems. The course will be punctuated by a rich set of mechanical system examples, ranging from violin string vibration to jet engines, from heart beats to vehicle control, and from population growth to nonlinear flight control. Prerequisite: MECH 436 or EECE 460.

MECH 650  Autonomous Mobile Robotics  3 cr.
This course is designed to provide engineering graduate and 4th year students with the opportunity to learn about autonomous mobile robotics. Topics include sensor modeling, vehicle state estimation, map-based localization, linear and nonlinear control, and simultaneous localization and mapping. Prerequisites: EECE 230, EECE 312, and MECH 435; or EECE 230 and MECH 460.

MECH 653  System Analysis and Design  3 cr.
A course that outlines state-space models of discrete and continuous, linear and nonlinear systems; controllability; observability; minimality; Eigenvector and transforms analysis of linear time invariant multi-input multi-output systems; pole shifting; computer control; design of controllers and observers. Prerequisite: MECH 436 or EECE 460 or equivalent.

MECH 654/655  Adaptive Control  3 cr.
A course that includes the control of partially known systems; analysis and design of adaptive control systems; self-tuning regulators; model reference adaptive control of uncertain dynamic systems; typical applications. Prerequisite: EECE 460 or MECH 436, or consent of instructor.
of combining renewable and non-renewable energy technologies in hybrid systems are analyzed. Design aspects of active, passive, wind, bio-energy, and photovoltaic energy conversion systems for buildings; and strategies for enhancing the future use of renewable energy resources are presented. The course will include several demonstrations of concept experiments. Prerequisite: MECH 310. Students cannot receive credit for both MECH 671 and EECE 675.

MECH 672 Modeling Energy Systems 3 cr.
A course that covers indoor space thermal models. The course also deals with the analysis and modeling of building energy systems involving applications of thermodynamics, economics, heat transfer, fluid flow and optimization. The use of modern computational tools to model thermal performance characteristics of components of HVAC systems including chillers, recovery systems, flow control devices, heat exchanges, solar panels, dehumidification systems, boilers, condensers, cooling towers, fans, duct systems, piping systems and pumps. The course will use modern simulation tools extensively. Prerequisite: MECH 310.

MECH 673 Energy Efficient Buildings with Good Indoor Air Quality 3 cr.
The course covers energy consumption standards and codes in buildings; energy conservation measures in built environment in order to enhance the building’s energy efficiency while maintaining space thermal comfort and indoor air quality requirements; fundamental ventilation, indoor-air-quality, infiltration natural and mechanical ventilation, importance and impact of indoor air quality on human health and energy performance of the building air conditioning system; and ASHRAE requirement for ventilation. Particular focus will be given to green energy alternative measures. An overview of the different heating, ventilation and air conditioning system designs is covered. Performance and energy consumption of the conventional air conditioning system (constant and variable air volume) as well as the hybrid integrated air conditioning systems will be discussed and compared. The course will include several demonstrations of concept experiments. Prerequisite: MECH 310.

MECH 674 Energy Economics and Policy 3 cr.
A course that aims at developing an understanding of practical analytical skills of energy economics and planning approaches taking into account the cost of impact on the environment. This course will cover fundamental concepts of economic issues and theories related to energy, such as economics of natural and energy resources, aggregate supply and demand analysis, and the interrelationship between energy, economics and the environment as well as some important issues in energy policy. The course will also demonstrate the use of economic tools for decision making in energy and environment planning and policy. It will explore the terminology, conventions, procedures and planning policy applications. It will also cover a number of contemporary energy and environmental policy issues, including energy security, global warming, regulations of energy industries, energy research and development, and energy technology commercialization. Prerequisite: ENGM 400. Students cannot receive credit for both MECH 674 and ECON 333.

MECH 675 Building Energy Management Systems 3 cr.
A course that provides an opportunity for students to explore topics in energy management systems and management strategies for new and existing buildings; energy use in buildings; energy systems analysis and methods for evaluating the energy system efficiency; energy audit programs and practices for buildings and facilities; initiating energy management programs; guidelines for methods of reducing energy usage in each area in buildings; conservation of the energy in the planning, design, installation, utilization, maintenance; control and automation of the mechanical systems in existing and new buildings; air conditioning and ventilation systems in buildings; assessment and optimization of energy control strategies; prediction methods of economic and environmental impact of implemented control strategies and indoor settings. Prerequisites: MECH 310 and MECH 412.

MECH 676 Passive Building Design 3 cr.
A course that centers on issues surrounding the integration of sustainable and passive design principles into conceptual and practical building design. Topics will include: solar geometry, climate/regional limitations, natural lighting, passive design and sustainability initiatives, insulating and energy storing material, and bioclimatic design and concepts. Case studies will be used extensively as a vehicle to discuss the success/failure of ideas and their physical applications. The course will focus on the use of energy auditing/modeling methods as means to both design and evaluate the relative “greenness” of buildings, as well as to understand the global implications of sustainable buildings. The course will include several demonstrations of concept experiments. Prerequisite: MECH 671.

MECH 677 Heat Pumps 3 cr.
A course that focuses on heat pumps in low energy and passive buildings as well as ground source heat pump fundamentals, loop systems, open systems, soil/rock classification and conductivity, grouting procedures, and performance of ground source heat pumps in housing units; water loop heat pumps, inside the building, bore holes, design and optimization of heat pump plants, including heat sources for such plants, and cost effective design options will also be considered. The course includes study visits and seminars given by industry experts. Prerequisite: MECH 310.

MECH 678 Solar Electricity 3 cr.
A course that focuses on the solar cell: photo generation of current, characteristic current-voltage (I-V) curve, equivalent circuit, effect of illumination intensity and temperature: the Photovoltaic (PV) generator: characteristic I-V curve of a PV generator, the PV module, connections of modules, support, safeguards, shadowing; the PV system: batteries, power conditioning. PV Systems: grid- connected and stand-alone systems, economics and sizing, reliability, applications; and manufacturing: preparation of crystalline silicon wafers, formation of contacts, coatings, construction of modules. The course will include several demonstrations of concept experiments. Prerequisite: EECE 210.

MECH 679 Energy Audit Lab 2 cr.
A course designed to give the students “hands-on” experience with carrying out energy audit measurements and studies on buildings to identify possible savings through selected energy conservation measures. Students will carry out measurements to investigate ventilation, air conditioning equipment, lighting and other office and lab equipment. Students will then be introduced to Visual DOE or E-Quest to perform energy simulation of buildings. Such tools will then be used to carry out a full building simulation taking into consideration occupancy data, equipment, lights, and building envelope. A base case of energy usage will thus be established and energy conservation is then applied to deduce possible savings and their economic value. Pre- or corequisite: MECH 672.
MECH 680  HVAC and Refrigeration Systems Lab  3cr.
The focus is on HVAC design optimization and energy conservation measures in built in environment. It includes concepts of district cooling/heating systems, dehumidification and personalized ventilation systems. This course has a major component of “hands-on” experience with building energy systems design, operation, and efficiency. The students will learn how to use and develop test equipment and plan for assessing system’s performance. Experiments and lab projects will span a series of advanced modules on sustainable, energy-efficient HVAC and refrigeration systems as laboratory topics. Lab topics may vary every semester. Pre-requisite: Advanced standing, MECH 310.

MECH 681  Green Buildings and Leed Practices  3cr.
In this course, students are exposed to green building concepts, design and construction practices, and building rating systems namely the LEED (Leadership in Energy and Environmental Design) system. Real-world LEED certified projects are considered to enforce conceptual information. The course will cover the equivalent of training modules offered by the US Green Building Council (USGBC). Pre-requisites: requires approval of the course coordinator.