Department of Mechanical Engineering

Chairperson:	Darwish, Marwan
Professors:	[P]Azoury, Pierre; Darwish, Marwan; Ghaddar, Nesreen K. (Qatar Chair in Energy Studies); Moukalled, Fadl
Professor Emeritus:	Sakkal, Fateh
Associate Professors:	Hamade, Ramsey; Kuran, Albert; Shihadeh, Alan
Assistant Professors:	Asmar, Daniel; Lakkis, Issam; Oweis, Ghanem; Shehadeh, Mutasem
Lecturers:	Abu Ghali, Kamel; Hajjhasan, Abdallah; Kasamani, Jihad; Kasti, Najb; Najm, Wajih; Nasereddine, Mohammad; Yousef, Basem
Instructor:	Seif, Cherbel
Assistant Instructors:	Ammouri, Ali; Kfoury, Elie
Secretary:	Najla Shaar

Undergraduate Program

Bachelor of Engineering: 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, 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 duration is equivalent to five academic years without the summer terms, but is completed in four calendar years.

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

- Information Technology offered by ECE
- Biomedical Engineering offered by ECE
- Engineering Management offered by EM Program

Other minors can be sought in the Faculty of Arts and Sciences and the Suliman S. Olayan School of Business.

P Part time

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.

Approved June 6, 1998, and revised October 19, 2000.

Program Educational Objectives

Students who attain a BE degree possess a tool chest of technical and non-technical skills and knowledge that positions them for success in professional practice as entry-level engineers in existing firms or graduate students in any program in the world, while having the aptitude to contribute to society. This does not preclude other activities, such as volunteerism, self-employment, or academic study in another discipline. Graduates succeed in this goal by a program that strives to:

- develop in students the ability to integrate mechanical engineering fundamentals with contemporary applications
- equip students with the ability to use modern experimental and computational tools in design and engineering practices
- motivate students to continually learn on their own, to think critically and creatively in order to allow them to evaluate new ideas, to identify problems, and to advance innovative solutions
- instill in the students the necessary interpersonal skills to perform professionally in a highly competitive and dynamically changing profession

Program Requirements

- **General Engineering:** CIVE 210, EECE 210, EECE 230, EECE 312, EECE 312L, ENMG 400
- **Mathematics:** MATH 201, MATH 202, MATH 212, MATH 218, MATH 251, STAT 230
- **Sciences:** PHYS 211, PHYS 211L, CHEM 202, CHEM 203, and one biology elective (BIOL 210, BIOL 290E, or any other 200 level biology course)
- **General Education:** Arabic course (based on APT), ENGL 206, one English elective, two social sciences courses, three humanities courses, ENMG 504 or a course on ethics
- **ME Core Courses:** MECH 200, MECH 220, MECH 230, MECH 310, MECH 314, MECH 320, MECH 332, MECH 340, MECH 341, MECH 410, MECH 412, MECH 414, MECH 420, MECH 421, MECH 430, MECH 431

- **Restricted Technical Electives:** One Design/Mechatronics Elective: MECH 520, MECH 522, or MECH 530. One Thermal/Fluid Systems Elective: MECH 510, MECH 511, or MECH 513
- **Technical Electives:** Five courses with at least three from the selected ME track. One elective can be from outside the major.
- **Approved Experience:** MECH 500
- **Final Year Project:** MECH 501 and MECH 502

Curriculum

Term I (Fall)			Credits
MATH	201	Calculus and Analytic Geometry III	3
CIVE	210	Statics	3
EECE	230	Computers and Programming	3
MECH	220	Engineering Graphics	1
PHYS	211	Electricity and Magnetism	3
PHYS	211L	Electricity and Magnetism Laboratory	1
ENGL	206	Technical English	3
			Total 17

Term II (Spring)			Credits
MATH	202	Differential Equations	3
MECH	200	Mechanical Engineering Tools	3
EECE	210	Electric Circuits	3
MECH	230	Dynamics	3
English Elective			3
			Total 15

Term III (Summer)			Credits
STAT	230	Introduction to Probability and Random Variables	3
CHEM	202	Introduction to Environmental Chemistry	3
CHEM	203	Introductory Chemical Techniques	2
			Total 8

Term IV (Fall)			Credits
EECE	312	Electronics	3
EECE	312L	Circuits and Electronics Lab	1
MATH	212	Vector Analysis, Fourier Series and PDE	3
MECH	310	Thermodynamics I	3
MECH	340	Engineering Materials	3
Humanities Elective			3
			Total 16

Term V (Spring)			Credits
MATH	218	Linear Algebra	3
MECH	314	Introduction to Fluid Mechanics	3
MECH	320	Mechanics of Materials	3
MECH	332	Mechanics of Machines (or MECH 430)	3
MECH	341	Materials Lab	1
Biology Elective			3
			Total 16

Term VI (Summer)			Credits
Humanities Elective			3
Arabic Elective			3
MECH 430		Instrumentation and Measurements (or MECH 332)	3
			Total 9

Term VII (Fall)			Credits
MATH	251	Numerical Computing	3
MECH	410	Thermal/Fluid Systems Laboratory	1
MECH	414	Thermodynamics II	3
MECH	420	Mechanical Design	3
MECH	421	Manufacturing Processes I	3
Social Sciences Elective			3
			Total 16

Term VIII (Spring)			Credits
ENMG	400	Engineering Economy	3
MECH	412	Heat Transfer	3
MECH	431	Control Systems	3
MECH	431L	Control Systems Laboratory	1
Restricted Design/Mechatronics Elective			
(MECH 520, MECH 522, or MECH 530)			3
Social Sciences Elective			3
			Total 16

Term IX (Summer)			Credits
MECH	500	Approved Experience	1b*

Term X (Fall)			Credits
ENMG	504	Engineering Ethics or any course on ethics	3
MECH	501	Final Year Project I	1
Restricted Thermal Fluid Sciences Elective			
(MECH 510, MECH 511, or MECH 513)			3
Technical Elective I			3
Technical Elective II			3
Humanities Elective			3
			Total 16

*b. stands for billing

Term XI (Spring)			Credits
MECH	502	Final year Project II	5
Technical Elective III			3
Technical Elective IV			3
Technical Elective V			3
			Total 14

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 by taking at least three technical electives in the selected track. Normally one technical elective is allowed from outside the mechanical engineering major.

Track I: Thermal and Fluid Engineering		
MECH 310	Thermodynamics I	3
MECH 314	Introduction to Fluid Mechanics	3
MECH 414	Thermodynamics II	3
MECH 410	Thermal/Fluid Systems Lab I	1
MECH 412	Heat Transfer	3
MECH 501	FYP I and MECH 502 FYP II	6
One restricted thermal/fluid systems elective		3
MECH 510	Modeling and Design of Thermal Systems	
MECH 511	Intermediate Fluid Mechanics	
MECH 513	Air Conditioning	
Technical Electives Courses (at least three technical electives are selected)		**Credits**
MECH 510	Modeling and Design of Thermal Systems	3
MECH 511	Intermediate Fluid Mechanics	3
MECH 512	Internal Combustion Engines	3
MECH 513	Air Conditioning	3
MECH 514	Gas Turbines	3
MECH 515	Steam Turbines	3
MECH 516	Aerodynamics	3
MECH 517	Energy Efficient Buildings	3
MECH 602	Energy Conservation and Utilization	3
MECH 603	Solar Energy	3
MECH 604	Refrigeration	3
MECH 606	Aerosol Dynamics	3
MECH 607	Micro Flows	3

Track II: Design, Materials, and Manufacturing		
CIVE 210	Statics	3
MECH 200	Mechanical Tools	3
MECH 220	Engineering Graphics	1
MECH 320	Mechanics of Materials	3
MECH 332	Mechanics of Machines	3
MECH 340	Engineering Materials	3
MECH 341	Materials Lab	1
MECH 420	Mechanical Design II	3
MECH 421	Manufacturing Processes I	3
MECH 501	FYP I and MECH 502 FYP II	6
One restricted design elective		3
MECH 520	Product Design and Development	
MECH 522	Mechanical CAD/CAE/CAM	
Technical Elective Courses (at least three technical electives are selected)		**Credits**
MECH 520	Product Design and Development	3
MECH 521	Manufacturing Processes II	3
MECH 522	Mechanical CAD/CAE/CAM	3
MECH 540	Selection of Properties of Materials	3
MECH 550	Computer Applications in Mechanical Engineering	3
MECH 622	Advanced Manufacturing Processes	3
MECH 624	Mechanics of Composite Materials	3
MECH 625	Fatigue of Materials	3
MECH 626	Metals and their Properties	3
MECH 627	Polymers and their Properties	3
MECH 628	Design of Mechanisms	3
MECH 633	Biomechanics	3
MECH 634	Biomaterials and Medical Devices	3

Track III: Mechatronics		
MECH 230	Dynamics	3
EECE 200	Electric Circuits	3
EECE 312	Electronics	3
EECE 312L	Circuits and Electronics Lab	1
MECH 430	Instrumentation and Measurements	3
MECH 431	Control Systems	3
MECH 431L	Control Systems Lab	1
MECH 501	FYP I and MECH 502 FYP II	6
One restricted mechatronics elective		**3**
MECH 530	Mechatronics System Design	

Technical Elective Courses (at least three technical electives are selected)		Credits
MECH 531	Mechanical Vibration	3
MECH 628	Design of Mechanisms	3
MECH 631	Micro-Electro Mechanical Systems (MEMS)	3
MECH 634	Biomaterials and Medical Devices	3
MECH 641	Robotics	3
MECH 642	Computer Vision	3
MECH 643	Mechatronics and Intelligent Machines Engineering II	3
MECH 644	Modal Analysis	3
MECH 645	Noise and Vibration Control	3

Course Descriptions

MECH 200 Mechanical Engineering Tools 3 cr.
This course introduces students to the mechanical engineering discipline, builds the student's interpersonal and communication skills, gives them insight into engineering concepts and creative design principles and an overview of engineering as a profession, together with ethics in engineering. It also introduces students to the creative process of identifying needs and devising practical solutions to fulfill those needs through designing, building, integrating, testing and evaluating an engineering product. Emphasis is placed on teamwork experiences. Students are familiarized with representative software and hardware tools that s/he is likely to utilize in process of product development.

MECH 220 Engineering Graphics 1 cr.
An introductory course in 2-D drawing, orthogonal projection, auxiliary views, sectioning and sectional views, dimensioning and tolerance schemes, standard drawing, layouts and AutoCAD. *Pre- or corequisite: none. Annually.*

MECH 230 Dynamics 3 cr.
A course on kinematics and kinetics of particles, systems of particles, rigid bodies in 2-D and 3-D motion, Newton's laws, work and energy, impulse and momentum, impact, and mass moments of inertia. *Pre- or corequisites: Math 201, CIVE 210.*

MECH 310 Thermodynamics I 3 cr.
A course on the thermodynamic state and properties of a pure substance, energy and mass conservation, entropy, and the second law; applications to closed setups and flow devices; simple vapor and gas cycles applications. *Prerequisite: discretion of adviser. Annually.*

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. Annually.*

MECH 320 Mechanics of Materials 3 cr.
A course on stresses, strains, and stress-strain relationship; tension and compression; torsion of circular bars; bending and shear in beams; combined stresses; stress transformation and Mohr's circle; stress concentration; stresses in pressurized cylinders; press and shrink fits; curved beams in bending; contact stresses; deflection and stiffness; deflection due to bending; beams deflection by superposition; beam deflection by singularity functions; Castigliano's theorem; deflection of curved beams; deflection in columns. *Prerequisite: 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; computer aided project. *Prerequisite: MECH 230. Annually.*

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. *Prerequisite: CIVE 210. Annually.*

MECH 341 Materials Lab 1 cr.
A laboratory course consisting of standard metallurgical and mechanical characterization tests on metals; stress-strain plots, derived properties, fracture toughness, crystallography, hardness, and other properties; ceramic flexure testing: Weibull plots; polymers: stress-strain plots and derived properties, impact properties, creep, and relaxation. *Prerequisite: MECH 340. Annually.*

MECH 410 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. Annually.*

MECH 412 Heat Transfer 3 cr.
A course investigating 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; thermal radiation, view factors and radiation exchange between diffuse and gray surfaces as well as the use of computer packages in problem solving. *Prerequisite: MECH 314. Annually.*

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. *Prerequisites: MECH 310 and CHEM 202. Annually.*

MECH 420 Mechanical Design 3 cr.
A course covering the analytical tools needed for the mechanical design of various machine components for rigidity and strength. The course deals with failure theories that result from static and variable loading; and the design of machine elements such as screws and joints, mechanical springs, bearings, gears, and shafts. Applications are covered through case studies and a team project. *Prerequisites: MECH 320 and MECH 340. Annually.*

MECH 421 Manufacturing Processes I 2.1; 3 cr.
A course on material removal processes, both traditional and non-traditional. Assembly processes such as welding, brazing, soldering, and fastening are also covered with an emphasis on process capabilities and limitations, relative cost, and guidelines for process selection. This course examines the behavior of materials under processing conditions and design, for manufacturing guidelines, and involves hands-on exercises in a machine shop environment. *Prerequisite: MECH 340. Annually.*

MECH 430 Instrumentation and Measurements 2.1; 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: MECH 230 and PHYS 211. Annually.*

MECH 431 Control Systems 3 cr.
This course is intended to provide students with the tools that enable them to model and control physical systems. It includes: modeling of physical systems; transfer function and block diagrams; time-domain analyses; root-locus; frequency-domain methods; stability analysis; design of PID controllers and dynamic compensators via the root locus and frequency methods. *Prerequisites: MECH 430 and EECE 210. Annually.*

MECH 431L Control Systems Laboratory 1 cr.
This course involves a series of hands-on experiments on modeling and design of control systems using Matlab, Simulink, and Labview. The course also includes a team project. *Prerequisite: MECH 430.*

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

MECH 501 Final Year Project I 1 cr.
A supervised project in groups of normally three students aimed at providing practical experience in some design aspects of mechanical engineering. Students are expected to complete a literature survey, to critically analyze, and to acquire the necessary material needed for their intended end product. *Prerequisite: discretion of adviser. Annually.*

MECH 502 Final Year Project II 5 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. Annually.*

MECH 503 Special Topics in Mechanical Engineering 3 cr.

MECH 510 Modeling and Design of Thermal Systems 2.1; 3 cr.
A course on the analysis, modeling, and design of engineered systems involving applications of thermodynamics, economics, heat transfer, and fluid flow; selection of components in fluid- and energy-processing systems to meet system performance requirements; system simulation and optimization techniques; use of modern computational tools to model thermal performance characteristics of components and systems. *Prerequisites: MECH 412.*

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 412.*

MECH 512 Internal Combustion Engines 2.1; 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. *Pre- 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 Energy Efficient Buildings 3 cr.
A course on integrated design process for low energy buildings. Introduces mechanical and architecture students to an integrated design approach to low energy buildings and to consideration of energy efficiency at all stages of design. The course defines and correlates the function of various building elements which effect low energy sustainability and make an environmentally friendly building. It also introduces participants to ecological criteria to impart an understanding of the building's role within the ecosystem. Students are exposed to hands-on experience in energy audit, interpretation of energy audit data, and performance of life cycle analysis for new and existing buildings. The multi-disciplinary background of students is a model for professional practice that promotes communication and understanding of architectural design processes by engineers and the understanding of the impact of architectural design on issues related to building loads, comfort, and building thermal response by the architect. *Pre- or corequisite: MECH 310 or PHYS 210 or consent of instructor. Annually.*

MECH 518 Environmental Challenges in Managing Ozone Depleting Substances 3 cr.
Introduction to environmental issues related to engineering. Review of selected multilateral agreements and, in particular, review of the Montreal Protocol with emphasis on compliance strategies and discussion of the current status of ozone depleting substances (ODS); also reviews available technologies that work best now, and future and alternative technologies. Applications are related to fire fighting, aerosols, solvents, foams and pesticides; management of ODS programs, good practices and safety issues. *Prerequisite: MECH 310 or equivalent.*

MECH 519 Compressible flow 3 cr.
This course covers general one-dimensional flow of a perfect gas homenergic and homentropic flow in nozzles and constant area ducts, normal shock waves, and one-dimensional unsteady gas flow. *Prerequisite: MECH 310.*

MECH 520 Product Design and Development 3 cr.
A course that covers modern tools and methods for product design and development. Teams of students conceive, design, and prototype a new physical product. Topics include identifying customer needs, product planning, product specifications, concept generation, industrial design, product architecture, product development economics, and design-for-manufacturing. *Prerequisites: MECH 332 and MECH 420. Annually.*

MECH 521 Manufacturing Processes II 2.1; 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.
A course that seeks to familiarize senior ME students with computer-aided design (CAD), computer-aided engineering (CAE), and computer-aided manufacturing (CAM) so that students become competent in using these powerful tools for mechanical engineering problem solving. The course utilizes several commercially available software packages. *Prerequisites: MECH 320 and MECH 420. Annually.*

MECH 530 Mechatronics System Design 2.1; 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: EECE 312 and MECH 430.*

MECH 531 Mechanical Vibrations 3 cr.
A course on free and forced response of non-damped and damped system; 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. *Prerequisites: MECH 230, an elementary course on Newtonian dynamics, or consent of instructor.*

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 elastic, plastic, viscoelastic behavior of materials; elements of creep, fatigue, and fracture mechanics. *Prerequisite: MECH 340. Annually.*

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 non-linear 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. *Prerequisite: MATH 202, MATH 251.*

MECH 602 Energy Conservation and Utilization 3 cr.
A course that deals with methods to reduce the losses and gains from a building envelope; energy conservation in cooling, heating, air-handling, and plumbing systems; energy management program. *Prerequisites: MECH 310, MECH 412. Alternate years.*

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. Alternate years.*

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

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, MECH 414, or consent of instructor. Alternate years.*

MECH 607 Micro Flows Fundamentals and Applications 3 cr.
A course on 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. Alternate years.*

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. Emphasis is on advance optical diagnostic techniques; namely particle image velocimetry (PIV), and laser induced fluorescence (LIF). The theoretical foundations of these techniques are established, and the discussion extended to practical considerations including software and hardware components. A few laboratory sessions are incorporated into the course to supplement the lectures and make use of the instruments available in the ME department, including the open circuit wind tunnel and the PIV system. In addition to the lectures and lab sessions, there is emphasis on the available literature. Prior knowledge of the basic principles of fluid mechanics and fluid systems is required. MATLAB is needed for course work. *Prerequisite: MECH 314.*

MECH 622 Advanced Manufacturing Processes 3 cr.
A course that deals with the underlying principles of material fabrication; metal machining: mechanics of cutting, materials, technology (tooling, CNC machining); phase change processes; deformation processes; non-traditional processes. *Prerequisite: MECH 421. Alternate years.*

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 equivalents. Alternate years.*

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. Alternate years.*

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. Alternate years.*

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 340. Alternate years.*

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. Alternate years.*

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 ALGOR general formulation and Galerkin approach; and analysis of field problems. *Prerequisites: MECH 420 and MATH 251. Alternate years.*

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 430. Alternate years.*

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. *Prerequisites: MECH 320 or CIVE 310, or consent of instructor. Annually.*

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. Annually.*

MECH 641 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. *Prerequisites: MECH 431. Annually.*

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

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. Alternate years.*

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. Alternate years.*

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. Alternate years.*

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 431 or equivalent. Alternate years.*

MECH 663 Computational Fluid Dynamics 3 cr.
A course that deals with discretization process in fluid dynamics, numerical approaches and applications, iterative and direct matrix methods and numerical implementation of turbulence models. *Prerequisites: MECH 314 and MECH 412. Alternate years.*

MECH 665 Unsteady Gas Flow 3 cr.
A course examining equations of unsteady continuous adiabatic multidimensional flows, unsteady continuous one-dimensional flow of a perfect gas with and without discontinuities, applications and pressure exchangers. *Prerequisite: MECH 414. Alternate years.*