DEPARTMENT OF MECHANICAL ENGINEERING

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MECHANICAL ENGINEERING (ME) PROGRAM

Mission

The Mechanical Engineering Department is devoted to educating exemplary mechanical engineers by instituting best learning practices that drive knowledge, build skills and competencies, inspire learners to define a purpose, develop a passion to forever learn, cultivate a sense of responsibility toward the profession, society and environment, and attain the ability to confront challenges, and in so doing contribute to the advancement of the community.

Program Educational Objectives

The educational objectives of the ME program are determined to support career advancement of the graduates and as they pursue their career goals, the graduates will:

1. be competent to handle complex engineering tasks and provide innovative solutions through the integration of best practices.
2. be recognized for their ability to pursue graduate studies in mechanical engineering and related interdisciplinary areas.
3. demonstrate leadership in their fields of expertise and service to local and international communities.

Student Outcomes

Upon completion of the program, graduates shall have developed:

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
3. an ability to communicate effectively with a range of audiences
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Degree Requirements

The undergraduate curriculum for the degree of Bachelor of Mechanical Engineering consists of 150 credit-hours of course work + IC3 (Internet and Computing Core Certification) + 30 credits transferred from Lebanese Baccalaureate or equivalent.

Career Opportunities

Mechanical engineers attain a broad spectrum of skills sought by almost every profession. Industries, enterprises, and service providers requiring mechanical engineering skills include: power generation and

distribution, building and construction, medicine and pharmacology, aerospace, automotive, food, process, security, computers and electronics, renewable energy, consulting, entertainment, water resources, sports, environmental institutions, and government. Most importantly, you can imagine something that never was and make it a reality! There is so much work to be done to guarantee the future of mankind and mechanical engineers can tap the possibilities through the spirit of innovation and entrepreneurism.

Program Overview

The student's study plan is given to every ME student upon his/her enrollment. The ME curriculum consists of the following components:

I. Common Requirements	**Credits**
General Education Requirements	20
Basic Sciences and Mathematics	26
General Engineering topics	15
II. ME Program-Specific Requirements	**Credits**
A. Engineering topics from outside the major	8
B. Mechanical Engineering Major	64
C. Mechanical Engineering Technical Electives	12
D. Final Year Project	4
E. Internship	1

I. Common Requirements

The list of the Common Requirements courses and their descriptions are presented in the introductory pages of the Faculty of Engineering section in this catalog.

The general engineering component includes 15 credits distributed as follows:

Course	Title	Credits	Prerequisite
COMP 208	Programming I	3	-
CVLE 210	Statics	3	-
INME 221	Engineering Economy	3	-
MCHE 201	Engineering Drawing and Graphics	3	-
MCHE 213	Dynamics	3	-

These two general engineering courses offered by the ME department are described below.

MCHE 201 ENGINEERING DRAWING AND GRAPHICS (3Crs.: 2Lec, 2Lab): Constructional Geometry-constructing tangents. Plane curves and polygons. Orthographic drawing and theory of sketching shapes and surface identification. Orthographic projection of views. Sectional views and conventions. Pictorial drawing. Applications of Auto-CAD software for 2D drawings.

MCHE 213 DYNAMICS (3Crs.: 3Lec, 0Lab) Dynamics of a particle, system of particles, and planar rigid bodies using Newton's law of motion. Work and energy principle, impulse and momentum principle. Free-body diagram and concept of equilibrium. Planar motion and kinematics of rigid bodies.

II. ME Program-Specific Requirements

A. Engineering topics from outside the major

This part of the ME curriculum includes 8-credit courses offered by other engineering programs. These courses are listed in the table below.

Course	Title	Credits	Pre-/Co-requisites
INME 211	Engineering Materials and Technology	3	Pre: PHYS 282
POWE 211	Electric Circuits (for Mechanical Engineering students)	3	Pre: PHYS 281

POWE 335	Electric Drives (for Mechanical Engineering students)	2	Pre: MCHE 214

Descriptions of this group of courses are given below.

INME 211 ENGINEERING MATERIALS AND TECHNOLOGY (3Crs.: 2Lec, 2Lab): Introduction to material and material properties, iron and steel. Structure of metals, principles of materials properties, theory of elasticity, metal alloys, strengthening by heat treatment, material selection for different engineering applications and micro structure of materials, ferrous materials, non-ferrous materials, polymers and composites. ***Pre-req.: PHYS 282.***

POWE 211 ELECTRIC CIRCUITS (for Mechanical Engineering students) (3Crs.: 3Lec, 0Lab): Circuit variables. Ohm's law. Kirchhoff's laws. Series and parallel resistors. Voltage and current divider circuits. Delta-to-Wye transformation. Node-voltage method. Mesh-current method, Thevenin equivalent circuit. Operational amplifiers. Sinusoidal steady-state analysis and power computations. Balanced-three phase circuits. Passive and active filter circuits. ***Pre-req.: PHYS 281.***

POWE 335 ELECTRIC DRIVES (for Mechanical Engineering students) (2Crs.: 2Lec, 0Lab): DC motors. DC motor drives. Single-phase and three-phase induction motors. Induction motor drives. Synchronous motors. Stepping motors. Universal motor. Switched-reluctance motors. ***Pre-req.: MCHE 214.***

B. Mechanical Engineering core courses

The Mechanical Engineering core courses are listed in the table below.

Course	Title	Credits	Pre-/Co-requisites
MCHE 214	Fundamentals of Mechatronics	2	Pre: POWE 211, Co: MCHE 214L
MCHE 214L	Fundamentals of Mechatronics Lab	1	Co: MCHE 214
MCHE 216	Dynamics of Machinery I	3	Pre: MCHE 213
MCHE 311	Mechanics of Materials	3	Pre: CVLE 210, Co: INME 211
MCHE 312	Machine Design I	3	Pre: MCHE 201 and MCHE 311
MCHE 315	Instrumentation and Measurement	2	Pre: MATH 381 and MCHE 214; Co: MCHE 315L
MCHE 315L	Instrumentation and Measurement Lab	1	Co: MCHE 315
MCHE 317	Dynamics of Machinery II	3	Pre: MCHE 216
MCHE 321	Thermodynamics I	3	Pre: PHYS 282
MCHE 322	Thermodynamics II	3	Pre: MCHE 321
MCHE 331	Fluid Mechanics I	3	Pre: PHYS 282
MCHE 332	Fluid Mechanics II	3	Pre: MCHE 331
MCHE 410	Mechanical Vibrations	3	Co: MCHE 418
MCHE 411	Machine Design II	3	Pre: MCHE 312, MCHE 317
MCHE 416	Mechatronics System Design	2	Pre: COMP 208, MCHE 315; Co: MCHE 416L, POWE 335
MCHE 416L	Mechatronics System Design Lab	1	Co: MCHE 416
MCHE 418	Dynamic Systems	3	Pre: MATH 283 and MCHE 317
MCHE 421	Heat Transfer	3	Pre: MATH 284, MCHE 321
MCHE 422	Refrigeration and Air Conditioning	3	Pre: MCHE 421
MCHE 429	Thermo-fluids Lab	2	Pre: MCHE 332, Co: MCHE 421
MCHE 500	Research Methodology	2	Co: ENGL 300
MCHE 515	Control Systems	2	Pre: MCHE 418, Co: MCHE 515L
MCHE 515L	Control Systems Lab	1	Co: MCHE 515
MCHE 521	Thermal Power Stations	3	Pre: MCHE 321, Co: MCHE 421
MCHE 531	Pump Technology	3	Pre: MCHE 332
MCHE 540	Fluid Thermal System Design	3	Pre: MCHE 531

Description of Core Courses

MCHE 214 FUNDAMENTALS OF MECHATRONICS (2Crs.: 2Lec, 0Lab): Introduction to mechatronic systems. Basic electronic components. Overview of analogue and digital electronic circuits. Semiconductors and the PN Junction. Diode circuits and applications. Rectification – half- and full-wave. Bipolar junction transistors. IGBT and MOSFET operation and circuits. Motor drives. Applications. ***Pre-req.: POWE 211, Co-req.: MCHE 214L***.

MCHE 214L FUNDAMENTALS OF MECHATRONICS LAB (1Cr.:0Lec,2Lab): Laboratory instruments; Basic electrical circuits; Thevenin and Norton equivalent circuits; Voltage divider and resistance bridge circuits; passive and active filters; Applications on diodes, bipolar transistors, and FET switching circuits; Applications on operational amplifiers and oscillators. ***Co-req.: MCHE 214.***

MCHE 216 DYNAMICS OF MACHINERY I (3Crs.: 3Lec, 0Lab): Machines and mechanisms. Principles of motion generation and introduction to the concepts of mobility, degrees of freedom and kinematic chains. Graphical linkage synthesis, path and function generation. Position, velocity and analysis of mechanisms. Kinetostatic analysis of rigid mechanisms. Computer-aided solutions. Project. ***Pre-req.: MCHE 213.***

MCHE 311 MECHANICS OF MATERIALS (3Crs.: 3Lec, 0Lab): Introduction to the mechanics of deformable bodies considering linear material response. Load-stress, stress-strain, and strain-displacement relations. Tension/compression of rods and trusses, torsion of shafts, bending in beams, bucking of columns, and pressure vessels. Analysis of combined loading. Mohr circle analysis. Stress-strain transformations. Statically indeterminate structures. ***Pre-req.: CVLE 210, Co-req.: INME 211.***

MCHE 312 MACHINE DESIGN I (3Crs.: 3Lec, 0Lab): Overview of the mechanical design process. Analytical concepts and tools for the design of machine elements. Failure theories. Design for strength under static and fatigue loading. Design for rigidity. Design of shafts. Design of non-permanent joints (fasteners and keys) and power screws. Design of permanent joints: rivets, welds and adhesive joints. Design of mechanical springs. Computer aided applications. ***Pre-req.: MCHE 201 and MCHE 311.***

MCHE 315 INSTRUMENTATION AND MEASUREMENT (2Cr.: 2Lec, 0Lab): Elements of a measurement system. Classification of sensors. Sensor characteristics. Sensor types. Statistical analysis of data, curve fitting, and uncertainty analysis. Physical principles. Interfacing concepts - amplification, filtering, A/D conversion. ***Pre-req.: MATH 381 and MCHE 214, Co-req.: MCHE 315L.***

MCHE 315L INSTRUMENTATION AND MEASUREMENT LAB (1Cr.: 0Lec, 2Lab): Introduction to LABVIEW. Experiments to measure various physical quantities. Data acquisition and analysis using NI-ELVIS platform. Typical laboratory experiments involve building signal conditioning circuits for thermocouples, thermistors, photodiodes, strain gauges, accelerometers, etc. Team project to design and develop a measurement system***. Co-req.: MCHE 315.***

MCHE 317 DYNAMICS OF MACHINERY II (3Crs.: 3Lec, 0Lab): Types of gears, gear tooth terminology and relations for spur, helical, bevel and worm gearing. Kinematic analysis and synthesis of ordinary and planetary gear trains. Types and synthesis of cam-follower mechanisms for specified follower motion. Balancing of mechanisms and rotating machinery. Flywheel design. Computer-aided solutions. Project. ***Pre-req.: MCHE 216.***

MCHE 321 THERMODYNAMICS I (3Crs.: 3Lec, 0Lab): Introduction and basic concepts. Properties of pure substances. Energy analysis of closed systems. Mass and energy analysis of control volumes. Second law of Thermodynamics. Heat engines and Carnot cycle. Refrigerators and heat pumps. Entropy Gas power cycles. Vapor refrigeration cycles. ***Pre-req.: PHYS 282.***

MCHE 322 THERMODYNAMICS II (3Crs.: 3Lec, 0Lab): Ideal and actual vapor power cycles. Rankine cycle parameters impact. Reheat and regenerative steam power cycles. Co-generation cycle concept. Steam flow through nozzles and turbines. Gas turbines (Regeneration, inter-cooling, and reheat cycles). Combined

power cycle. Research by topics. ***Pre-req.: MCHE 321.***

MCHE 331 FLUID MECHANICS I (3Crs.: 3Lec, 0Lab): Introduction to Fluid Mechanics, Fluid properties, Fluid static, Forces on immersed surfaces, buoyancy and stability of floating bodies, fluid masses subjected to acceleration, vortex motion. Basic fluid dynamic equation, Continuity equation, Bernoulli's equation, Bernoulli's equation application. Fluid flow in pipelines, pipe losses, major and minor losses calculation, series and parallel pipes. ***Pre-req.: PHYS 282.***

MCHE 332 FLUID MECHANICS II (3Crs.: 3Lec, 0Lab): Dimension analysis using PI-Theorem. Fluid flow kinematics for three- dimensional fluid motions, velocity potential, Basic and combined flow field applications, Continuity equation. Lift and Drag forces. Navier-Stokes equations, Applications on Navier-Stokes equations. ***Pre-req.: MCHE 331.***

MCHE 410 MECHANICAL VIBRATIONS (3Crs.: 3Lec, 0Lab): Introduction to vibration. Equivalent systems. Harmonic motion. Free and forced vibrations of single degree of freedom systems, rotating unbalance and base excitation. Two degree of freedom systems. Lagrange's equations. Vibration of multi degree of freedom (MDOF) systems through the calculation of eigenvalues and mode shapes (Modal analysis). Vibration measurements. Practical applications. ***Co-req.: MCHE 418.***

MCHE 411 MACHINE DESIGN II (3Crs.: 3Lec, 0Lab): Analysis and synthesis of various types of gear trains. Geometry and force analysis of helical, bevel and worm gears and gear trains. Design of gear drives for strength using AGMA standards for spur, helical, bevel and worm gearing. Rolling-contact bearings. Design of belt and chain drives. Design of clutches and brakes. Team project to formulate and design a mechanical system for a useful purpose. ***Pre-req.: MCHE 312 and MCHE 317.***

MCHE 416 MECHATRONICS SYSTEM DESIGN (2Crs.: 2Lec, 0Lab): Structure of mechatronic systems; Architecture of microcontrollers; A/D and D/A conversion; Interfacing analog and digital sensors; Controlling actuators using power interface; Servo and stepper motors control; Case studies on mechatronic systems design. ***Pre-req.: COMP 208 and MCHE 315, Co-req.: POWE 335 and MCHE 416L.***

MCHE 416L MECHATRONICS SYSTEM DESIGN LAB (1Cr.: 0Lec, 2Lab): Arduino board architecture; Arduino programming language; Analog and digital I/O; Data acquisition from analog and digital sensors; Serial connection; Servo and stepper motors interfacing and control; Data display; Team project to develop a mechatronic system. ***Co-req.: MCHE 416.***

MCHE 418 DYNAMIC SYSTEMS (3Crs.: 3Lec, 0Lab): Introduction to dynamic modeling of mechanical, electrical, thermal and fluid systems. State-space equations. Analysis of linear systems. Time- and frequency-domain analysis. Laplace transform techniques. Nonlinear systems. Introduction to dynamic systems characteristics and performance. Simulation using Matlab and Simulink. ***Pre-req.: MATH 283 and MCHE 317.***

MCHE 421 HEAT TRANSFER (3Crs.: 3Lec, 0Lab): Concepts and laws of conduction, convection and radiation heat transfer and their application to solving engineering thermal problems. Steady and transient heat conduction. Heat generation. Extended surfaces. External and internal forced convection of laminar and turbulent flows. Natural convection. Thermal radiation, view factors, and radiation exchange between gray bodies. ***Pre-req.: MATH 284 and MCHE 321.***

MCHE 422 REFRIGERATION AND AIR CONDITIONING (3Crs.: 3Lec, 0Lab): Refrigeration introduction and fundamentals, Basic refrigeration cycles, different types of central/unitary air conditioning systems (DX-unit, chillers, and VRV systems). Psychometric air properties, air-conditioning processes, air conditioning cycles analysis. Fundamentals of HVAC system design, cooling/heating load estimation, analysis of applied psychometrics charts, schematic design of HVAC system, equipment selection, air duct design. Fan types. Noise criteria and analysis. ***Pre-req.: MCHE 421.***

MCHE 429 THERMO-FLUIDS LAB (2Crs.: 0Lec, 4Lab): Experiments relevant to thermodynamics, heat transfer, fluid systems and hydraulic machines. Measurement of temperature, thermal conductivity,

convective heat transfer coefficients, and heat radiation. In addition to experiments on air conditioning unit, Francis and Pelton turbines, pressure measurement device, process trainer, and diesel engine. ***Pre-req.: MCHE 332, Co-req.: MCHE 421.***

MCHE 500 RESEARCH METHODOLOGY (2Crs.: 2Lec, 0Lab): Steps for conducting a successful research: formulating a research problem, conceptualizing a research design, constructing an instrument for data collection, writing a research proposal, collecting data, processing & displaying data, writing a research report. ***Co-req.: ENGL 300.***

MCHE 515 CONTROL SYSTEMS (2Crs.: 2Lec, 0Lab): Transfer function for various dynamic systems. Block reduction techniques. Performance of first-, second-, and higher-order systems. Steady-state error. Stability analysis and Routh-Hurwitz criterion. Root-locus techniques. Design of controllers and compensators. Frequency response and Bode plots. ***Pre-req.: MCHE 418, Co-req.: MCHE 515L.***

MCHE 515L CONTROL SYSTEMS LAB (1Cr.: 0Lec, 2Lab): Analysis of various control systems in Matlab and Simulink. Design of PID controllers using the control toolbox. Control experiments that includes: DC Motor and inverted pendulum. Team project. ***Co-req.: MCHE 515.***

MCHE 521 THERMAL POWER STATIONS (3Crs.: 3Lec, 0Lab): Introduction to thermal power station. Types of thermal power station. Demonstration of simple Rankine cycle, impact of key parameters variation on cycle performance, review of modified Rankine cycles (reheat cycle, regenerative cycle, and co-generation cycle). Thermal analysis and design of the various components of the steam power plants (steam generator – steam condenser – cooling tower – feed water heaters) are given in details. Gas-turbine cycle and combined cycle. Concentrating solar collector analysis and design. ***Pre-req.: MCHE 321, Co-req.: MCHE421.***

MCHE 531 PUMP TECHNOLOGY (3Crs.: 3Lec, 0Lab): Introduction to pumps. Pump classifications. Centrifugal pump construction. Pump performance curves, operating points, discharge regulation, similarity law, speed variation, velocity triangle and cavitation. Pumps in series and parallel. Multi-stage pumps, axial flow pumps. Viscosity density and temperature effect on the pump performance. Specific speed. Effect of air entraining vortex from pump suction side. Priming of pumps. Axial, radial and mixed flow pumps design. Forces acting on different rotating elements, gland packing seals and mechanical seals. Pump system design project. ***Pre-req.: MCHE 332.***

MCHE 540 FLUID THERMAL SYSTEM DESIGN (3Crs.: 3Lec, 0Lab): Specifications of fans, compressors, and blowers. Design, operation and fans selection for ventilation systems. Fire pumps specifications and safety codes based on NFPA 20. Mechanical specification codes and standards used in the mechanical services in building. Pump stations design. Pipe network systems. Water hammer protection causes effect & solution. Application of fluid thermal (space air heating application) such as radiator systems including pipe sizing and selection of boiler, pump, and radiators. High-rise building water distribution riser diagram. Chiller piping system applications (constant primary, constant primary-variable secondary, variable primary). Course Projects in the implementing of fluid thermal systems design and plumbing. ***Pre-req.: MCHE 531.***

C. Mechanical Engineering Technical Electives

The ME curriculum includes four 3-credit hour courses as technical electives. The courses are chosen from the courses listed in the table below with their descriptions given thereafter.

Course	Title	Credits	Pre-/Co-requisites
MCHE 513	Finite Element Analysis – Theory and Applications	3	Pre: MCHE 312
MCHE 514	Programmable Logic Controllers	3	Pre: MCHE 315
MCHE 517	Design of Planar Mechanisms	3	Pre: MCHE 317
MCHE 518	Product Design and Development	3	Pre: MCHE 411

MCHE 523	Thermal Equipment Design	3	Pre: MCHE 421
MCHE 525	Renewable Energy Technologies	3	Pre: MCHE 321
MCHE 526	Energy Management	3	Pre: MCHE 321
MCHE 528	Aircraft Engines	3	Pre: MCHE 322
MCHE 534	Pipeline Engineering	3	Pre: MCHE 331 or MCHE 339
MCHE 533	Hydraulic Machinery and Stations	3	Pre: MCHE 331
MCHE 535	Hydraulic Circuits	3	Pre: MCHE 331
MCHE 536	Hydraulic Equipment	3	Pre: MCHE 535
MCHE 537	Pneumatic Circuits and Applications	3	Pre: MCHE 331
MCHE 539	Gas Dynamics	3	Pre: MCHE 321 and MCHE 331
MCHE 560	Mobile Robotics	3	Co: MCHE 416
MCHE 562	Sensors and Actuators	3	Pre: MCHE 315
MCHE 563	Applied Engineering Optimization	3	Pre: MATH 284 and MCHE 312
MCHE 564	Automotive Engineering	3	
MCHE 565	Technology Ventures	3	Pre: MGMT 002 and INME 221
MCHE 566	Automotive Control	3	Pre: MCHE 564
MCHE 567	Fundamentals of Robotics	3	Pre: MCHE 317 or COMP 328
MCHE 571	Refrigeration and HVAC Applications	3	Pre: MCHE 422
MCHE 572	Water Desalination Technologies	3	MCHE 421
MCHE 573	Operation and management of Thermal Power Stations	3	Pre: MCHE 521
MCHE 574	Acoustical Analysis of Mechanical Systems	3	Pre: MCHE 315 and MCHE 422
MCHE 575	REVIT MEP For Mechanical Engineers	3	Pre: MCHE 422
MCHE 581	Computational Fluid Dynamics	3	Pre: MCHE 321 and MCHE 331
INME 312	Computer Aided Design and Manufacturing	3	Pre: MCHE 201

Description of Technical Elective Courses

MCHE 513 FINITE ELEMENT ANALYSIS – THEORY AND APPLICATIONS (3Crs.: 3Lec, 0Lab): Introduction to the theoretical basis of finite element method and its application in solving engineering problems. Topics covered include: Overview of the finite element solution; basic finite elements; modeling considerations; static, modal and dynamic analysis of structures and mechanical systems; solution of field problems; commercial finite element software package. Project. ***Pre-req.: MCHE 312.***

MCHE 514 PROGRAMMABLE LOGIC CONTROLLERS (3Crs.: 3Lec, 0Lab): PLC operation. PLC memory; Ladder logic; structured logic, flowchart-based, and state-based design; instruction list and structured text programming; Interface of sensors, actuators, and I/O devices; selecting PLC; development of PLC-based systems; lab experiments. Projects. ***Pre-req.: MCHE 315.***

MCHE 517 DESIGN OF PLANAR MECHANISMS (3Crs.: 3Lec, 0Lab): Kinematics chains, creation of mechanisms, and mobility analysis, synthesis of single- and multi-loop mechanisms for various motion requirements, synthesis of multi-loop mechanisms, synthesis of geared-linkage mechanisms, Synthesis of mechanisms for instantaneous motion generation, Optimum synthesis of mechanisms. Computer-aided analysis and synthesis. Project. ***Pre-req.: MCHE 317.***

MCHE 518 PRODUCT DESIGN AND DEVELOPMENT (3Crs.: 3Lec, 0Lab): Modern tools and methods involving product design and development process. Product planning; Idea generation; concept generation; concept selection; functional analysis; engineering design process for systems and components; economic and environmental considerations; reliability analysis; product safety; Team project to transform idea into a product. ***Pre-req.: MCHE 411***.

MCHE 523 THERMAL EQUIPMENT DESIGN (3Crs.: 3Lec, 0Lab): Introduction to heat exchangers. LMTD method. ε-NTU method. Heat transfer and pressure drop correlations. Double-pipe heat exchangers. Shell-and-tube heat exchangers. Compact heat exchanger design (dry cooler, cooling and dehumidifying coil,

indirect evaporative cooler). Direct contact heat exchangers. Computer applications. ***Pre-req.: MCHE 421.***

MCHE 525 RENEWABLE ENERGY TECHNOLOGIES (3Crs.: 3Lec, 0Lab): Overview of the main renewable energy sources including solar energy, wind energy, geothermal energy, hydro-energy, biofuel and biomass, and ocean energy. Solar angles, estimation of hourly and daily solar radiation, selected heat transfer topics, energy storage, flat-plate solar collector, solar building-heating active and passive, concentrating collector, wind energy, introduction to alternative energy technologies such as hydro, geothermal, and ocean thermal energy conversion. Engineering economy and environmental impact of utilization of renewable energy systems will be also discussed. ***Pre-req.: MCHE 321.***

MCHE 526 ENERGY MANAGEMENT (3Crs.: 3Lec, 0Lab): The course introduces the concepts and techniques of energy management and conservation based on the national statistics of energy supply and demand. Scope of the energy problems and approaches to provide solutions; energy auditing; improving energy utilization in space conditioning and steam, hot water and compressed air systems; energy savings opportunities in refrigeration and cooling systems; insulation; lighting efficiency technique, use of waste thermal energy systems for domestic and industrial applications, and electrical energy conservation are highlighted. ***Pre-req.: MCHE 321.***

MCHE 528 AIRCRAFT ENGINES (3Crs.: 3Lec, 0Lab): Introduction to air propulsion engine. Air propulsion principles. Performance of turbojet, turbofan, and turbo-propeller engines. Design of main components of aircraft engines including air intake, compressor, turbine, and nozzle. Gas turbine cycle for aircraft applications. Estimating engine thrust, engine fuel consumption and efficiencies. Comparing types of combustion chambers. ***Pre-req.: MCHE 322.***

MCHE 534 PIPELINE ENGINEERING (3Crs.: 3Lec, 0Lab): Introduction to Pipeline engineering, Specification, selection of pipes and material, Piping system analysis, Unsteady flow in pipe systems. Piping Codes and standards, Instrumentation and measurements. Pipeline protection, and coating. Introduction to installation, operation, backfilling, cleaning, monitoring and maintenance. Pipeline testing, Piping supports, General requirements of pipes used in Oil and Gas industries, Transportation of oil using centrifugal pumps. Gas pipelines. ***Pre-req.: MCHE 331 or MCHE 339.***

MCHE 533 HYDRAULIC MACHINERY AND STATIONS (3Crs.: 3Lec, 0Lab):): Introduction to water turbines. Types of Hydraulic turbines, Pelton wheel, Francis, propeller and Kaplan turbines, construction, design factors, discharge regulation and part load performance, velocity diagram, power, efficiency, model testing, cavitations and turbine selection, pump storage projects, mini-water turbines. Hydro-power plants in Lebanon. ***Pre-req.: MCHE 331.***

MCHE 535 HYDRAULIC CIRCUITS (3Crs.: 2Lec, 2Lab): Design of basic hydraulic circuits, elements of hydraulic circuits and design factors, Positive displacement oil pumps as sources of hydraulic power, oil reservoirs, pipes, control valves: pressure, direction and flow control, fluid power actuators: hydraulic cylinders, hydraulic motors, standard symbols according to ANSI Standard and graphical representation, basic hydraulic circuits and applications in practice. ***Pre-req.: MCHE 331.***

MCHE 536 HYDRAULIC EQUIPMENT (3Crs.: 3Lec, 0Lab): Hydraulic system design, design problems & analysis, applications: hydraulic presses, shearing machines, hydraulic cranes, hydraulic lifts, loaders, excavators, mixers, concrete pump, pile drilling machine, hydraulic equipment maintenance and troubleshooting. ***Pre-req.: MCHE 535.***

MCHE 537 PNEUMATIC CIRCUITS AND APPLICATIONS (3Crs.: 3Lec, 0Lab): An overview of compressed air systems, Compressor types, Air treatment devices: dryers, filters. Elements of pneumatic circuits and design factors, Compressed air characteristics, System components, Compressors, Air reservoirs, Actuators, Cylinders, Motors, Pneumatic system control, Standard symbols and graphical representation, Basic pneumatic circuits and applications in practice. ***Pre-req.: MCHE 331.***

MCHE 539 GAS DYNAMICS (3Crs.: 3Lec, 0Lab): Introduction to compressible flow. Speed of sound in gases and liquids. Stagnation state for ideal gas model. Isentropic flow in convergent and convergent-

divergent nozzles. Variation of fluid properties with Mach number for subsonic and supersonic flows. Governing equations and analysis of normal and oblique shock waves in supersonic flow. Analysis of adiabatic flow in ducts with friction (Fanno model). Describing frictionless flow in ducts with heat transfer (Raylieh model). Applications of gas dynamics in jet engines. ***Pre-req.: MCHE 321 and MCHE 331.***

MCHE 560 MOBILE ROBOTICS (3Crs.: 3Lec, 0Lab): Key issues for locomotion: legged and wheeled mobile robots; Mobile robot kinematics: mobility, steerability, maneuverability; Sensors for mobile robots' perception and localization; Introduction to autonomous mobile robots: path planning, obstacle avoidance and navigation. ***Co-req.: MCHE 416.***

MCHE 562 SENSORS AND ACTUATORS (3Crs.: 3Lec, 0Lab): Introduction to contemporary sensor and actuator technologies. Smart sensor and actuator materials (piezoelectric, shape memory alloys, electro-rheological, etc.). Application Specific Integrated Circuits (ASIC). Smart sensors and sensor fusion. Project. ***Pre-req.: MCHE 315.***

MCHE 563 APPLIED ENGINEERING OPTIMIZATION (3Crs.: 3Lec, 0Lab): Problem definition, objective functions and constraint; local vs. global optimization methods; deterministic vs. stochastic methods; linear and non-linear programming methods; gradient-based methods; combinatorial optimization techniques: Genetic algorithm, simulated annealing, tabu search, and ant colony; applications to various mechanical engineering problems; computer-aided solutions; project. ***Pre-req.: MATH 281 and MCHE 312.***

MCHE 564 AUTOMOTIVE ENGINEERING (3Crs.: 3Lec, 0Lab): Engine parts and construction. Engine classifications. Estimation of engine power, fuel consumption and efficiencies. Engine combustion and emissions. Carburetor and electronic fuel injection systems. Mechanical and electronic ignition systems. Engine cooling and lubrication systems. Automotive disc and drum brakes. Power brakes. Anti-lock brake system (ABS). Automotive manual and power steering systems. Conventional, air, and active suspension systems. Four wheel steering. Components of power train including Clutches, transmission, and differential.

MCHE 565 TECHNOLOGY VENTURES (3Crs.: 3Lec, 0Lab): This course teaches students how to articulate a well-reasoned, easily understood business plan, understand the product realization process, set and achieve targets, prepare budgets, find capital by effectively communicating the idea to those who can finance it, hire the right mix of marketing and technical talent, know the market by engaging in real time market research, and focus on the customer; team project. ***Pre-req.: MGMT 002 and INME 221.***

MCHE 566 AUTOMOTIVE CONTROL (3Crs.: 3Lec, 0Lab): Concepts of automotive control, Electro-mechanical systems that are controlled by electronic control modules via an appropriate algorithm such as fuel injection timing control, emission control, transmission clutch control, anti-lock brake control, traction control, stability control, etc. ***Pre-req.: MCHE 564.***

MCHE 567 FUNDAMENTALS OF ROBOTICS (3Crs.: 3Lec, 0Lab): Robot architecture, subsystems, and applications; mechanisms and drives; forward and inverse kinematics. Trajectory planning; dynamics and control. Metrics of robot performance. Serial and parallel-drive manipulators. Static force and torque analysis. Computer-aided analysis. ***Pre-req.: MCHE 317 or COMP 328.***

MCHE 571 REFRIGERATION AND HVAC APPLICATIONS (3Crs.: 2Lec, 2Lab): Refrigeration cycles, Multi-stage compression cycles, compressor types and selection, metering device selection, evaporator selection and design, condenser selection and design. Basic cycle performance, suction accumulator. Liquid receiver, oil separator, multi evaporators design, and different defrost methods. Refrigerant piping design, chilled and hot water piping design, cold stores planning, cooling load calculations for cold store, cold store insulation. Refrigeration equipment selection and installation. Air conditioning systems selection. Air duct design. Course project. Computer software. ***Pre-req.: MCHE 422.***

MCHE 572 WATER DESALINATION TECHNOLOGIES (3Crs.: 3Lec, 0Lab): The course provides theoretical and practical aspects of seawater/brackish water desalination technologies. The main topics include basic concepts of water chemistry; detailed evaluation and technology description of thermal-based (SSE, MEV, MSF, MED, and VC) and membrane-based (RO) desalination processes; conventional and

innovative intake and pre-treatment systems; process design and system performance; fouling, scaling (including bio-fouling) and cleaning; product water quality and post-treatment. Other related topics such as innovative desalination technologies (Forward Osmosis (FO), Membrane Distillation (MD), Absorption/adsorption Desalination; energy consumption; environmental impact; economics; hybrid systems; desalination using renewable energy; trends of desalination market; full scale plants and case studies, will also be covered in this course depending on time availability. ***Pre-req.: MCHE 421.***

MCHE 573 OPERATION AND MANAGEMENT OF THERMAL POWER STATIONS (3Crs.: 3Lec, 0Lab): Various systems and cycles used in producing electrical power. Boiler operation and control, boiler testing and maintenance, water treatment procedure, condenser operation and troubleshooting, steam turbine construction, steam turbine governing systems types and operation, gas turbine operation and control, variable load management and power plants economics and power distribution systems. ***Pre-req.: MCHE 521.***

MCHE 574 ACOUSTICAL ANALYSIS OF MECHANICAL SYSTEMS (3Crs.: 3Lec, 0Lab): Fundamentals of Acoustics and Acoustic Measurements; Sound Propagation and Decibel Scale, Sound Power Level, The Ear and Assessment of Loudness, Quantifying Loudness. Community Reaction to Noise; Noise Annoyance, Noise Standards and Legal Aspects, Controlling Level Outsides Buildings. Behaviour of Sound Inside Buildings; Calculation of Room Noise Levels, Sound Transmission Through Partitions. Noise in Ductwork Systems; Fan Noise, Ductwork Attenuation, Ductwork Acoustic Calculations. Computer software applications. ***Pre-req.: MCHE 315 and MCHE 422.***

MCHE 575 REVIT MEP FOR MECHANICAL ENGINEERS (3Crs.:0Lec, 6 Lab): The aim of this course is to effectively communicate building information using Autodesk Revit software for mechanical and plumbing systems of building structures. Principles and applications of MEP modeling and documentation. Revit project setup for engineering purposes. Work sharing concepts, methods, tools and commands with Revit for building design, construction documentation and presentation purposes. Topics include working with interrelated architectural files where students learn how to add mechanical equipment to a Mechanical Services project, create HVAC zones, add insulation, piping systems, fire protection systems and more**.** ***Pre-req.: MCHE 422.***

MCHE 581 COMPUTATIONAL FLUID DYNAMICS (3Crs.: 3Lec, 0Lab): Introduction to the methods and analysis techniques used in computational solutions of fluid mechanics and heat transfer problems; finite difference method; partial differential equations; discretization approaches; stability, consistency, and convergence; finite-volume formulations; explicit and implicit methods; code and solution verification; incompressible flows; validation and uncertainty quantification; simulation and design using commercial CFD code. ***Pre-req.: MCHE 321 and MCHE 331.***

INME 312 COMPUTER AIDED DESIGN AND MANUFACTURING (3Crs:1Lec, 4Lab): Geometric/solid modeling, design optimization, graphical and computational features of CAD, engineering analysis and design execution and implementation, manual code programming G code, finite element analysis (FEA). ***Pre-req.: MECH201.***

D. Final Year Project

MCHE 501 FINAL YEAR PROJECT I (1Cr) / MCHE 502 FINAL YEAR PROJECT II (3Crs) After completing 114 credits of course work, the student becomes eligible to sign up for the Final Year Project (FYP) that extends over two semesters; beginning in fall semester and ending in the following spring semester. The FYP experience requires students to work in teams to complete a specific project, submit a technical report, and give a presentation on a significant, relevant, and comprehensive engineering problem. The FYP is intended to stimulate student innovation and critical thinking, and build skills in formulating, designing, developing, building, communicating, and managing engineering projects. The project aims to provide students with a transitional experience from the academic world to the professional world.

E. Internship (Approved Experience/ Faculty-Supervised Project)

MCHE 499 INTERNSHIP (1Cr): professional training which should not be less than four weeks. The training is followed by a presentation session where the students are supposed to present what they have learned.

Study Plan
Bachelor of Engineering in Mechanical Engineering (150 Credits)

First Semester (16 credit hours)		**Crs.**	**Pre/Co-requisites**
BLAW 001	Human Rights	1	
CHEM 241	Principles of Chemistry	3	
MATH 281	Linear Algebra	3	
MCHE 201	Engineering Drawing and Graphics	3	
MCHE 213	Dynamics	3	
PHYS 282	Material Properties and Heat	3	

Second Semester (18 credit hours)		**Crs.**	**Pre/Co-requisites**
COMP 208	Programming I	3	
CVLE 210	Statics	3	
INME 211	Engineering Materials and Technology	3	Pre: PHYS 282
MATH 282	Calculus	3	
MCHE 216	Dynamics of Machinery I	3	Pre: MCHE 213
PHYS 281	Electricity and Magnetism	3	

Summer 1 (8 credit hours)		**Crs.**	**Pre/Co-requisites**
ARAB 001	Arabic Language	2	
ENGL 001	General English	2	
	General Electives[1]	4	

Third Semester (18 credit hours)		**Crs.**	**Pre/Co-requisites**
MATH 283	Differential Equations	3	Pre: MATH 281, MATH 282
MCHE 311	Mechanics of Materials	3	Pre: CVLE 210, Co: INME 211
MCHE 317	Dynamics of Machinery II	3	Pre: MCHE 216
MCHE 321	Thermodynamics I	3	Pre: PHYS 282
MCHE 331	Fluid Mechanics I	3	Pre: PHYS 282
POWE 211	Electric Circuits (for Mechanical Engineering students)	3	Pre: PHYS 281

Fourth Semester (18 credit hours)		**Crs.**	**Pre/Co-requisites**
MATH 284	Numerical Analysis	3	Pre: MATH 283
MATH 381	Probability and Statistics	3	Pre: MATH 282
MCHE 214	Fundamentals of Mechatronics	2	Pre: POWE 211, Co: MCHE 214L
MCHE 214L	Fundamentals of Mechatronics Lab	1	Co: MCHE 214
MCHE 312	Machine Design I	3	Pre: MCHE 201 and MCHE 311
MCHE 322	Thermodynamics II	3	Pre: MCHE 321
MCHE 332	Fluid Mechanics II	3	Pre: MCHE 331

Summer 2 (8 credit hours)		**Crs.**	**Pre/Co-requisites**
ENGL 211	Advanced Writing	2	Pre: ENGL 001

MGMT 002	Entrepreneurship I	2	
	General Electives[1]	4	

Fifth Semester (18 credit hours)		**Crs.**	**Pre/Co-requisites**
ENGL 300	Speech Communications	2	Pre: ENGL 211
CHEM 405	Solid State Chemistry	2	Pre: CHEM 241
INME 221	Engineering Economy	3	
MCHE 315	Instrumentation and Measurement	2	Pre: MATH 381 and MCHE 214 Co: MCHE 315L
MCHE 315L	Instrumentation and Measurement Lab	1	Co: MCHE 315
MCHE 411	Machine Design II	3	Pre: MCHE 312, MCHE 317
MCHE 421	Heat Transfer	3	Pre: MATH 284, MCHE 321
MCHE 429	Thermo-fluids Lab	2	Pre: MCHE 332, Co: MCHE 421

Sixth Semester (17 credit hours)		**Crs.**	**Pre/Co-requisites**
MCHE 410	Mechanical Vibrations	3	Co: MCHE 418
MCHE 416	Mechatronics System Design	2	Pre: COMP 208, MCHE 315, Co: MCHE 416L, POWE 335
MCHE 416L	Mechatronics System Design Lab	1	Co: MCHE 416
MCHE 418	Dynamic Systems	3	Pre: MATH 283, MCHE 317
MCHE 422	Refrigeration and Air Conditioning	3	Pre: MCHE 421
POWE 335	Electric Drives (for Mechanical Engineering)	2	Pre: MCHE 214
	Technical Elective[2]	3	

Summer 3 (1 credit hour)		**Crs.**	**Pre/Co-requisites**
MCHE 499	Internship	1	

Seventh Semester (15 credit hours)		**Crs.**	**Pre/Co-requisites**
MCHE 500	Research Methodology	2	Co: ENGL 300
MCHE 501	Final Year Project I	1	Pre: INME221, Co: MCHE 500
MCHE 515	Control Systems	2	Pre: MCHE 418, Co: MCHE 515L
MCHE 515L	Control Systems Lab	1	Co: MCHE 515
MCHE 521	Thermal Power Stations	3	Pre: MCHE 321, Co: MCHE 421
MCHE 531	Pump Technology	3	Pre: MCHE 332
	Technical Elective[2]	3	

Eighth Semester (13 credit hours)		**Crs.**	**Pre/Co-requisites**
ENGR 001	Engineering Ethics	1	
MCHE 502	Final Year Project II	3	Pre: MCHE 501
MCHE 540	Fluid Thermal System Design	3	Pre: MCHE 531
	Technical Electives[2]	6	

[1] selected form the list of university elective courses.
[2] selected form the list of Mechanical Engineering elective courses.

Courses offered for other majors
The Mechanical Engineering Department offers three courses for other engineering majors. These courses are described below.

MCHE 202 MECHANICAL ENGINEERING FOR BUILDINGS (3Crs.: 3Lec, 0Lab): Water supply for buildings; pumping systems; plumbing; waste systems; sump pumps; heat losses and thermal insulation; ventilation and air conditioning; sound insulation; elevators and escalators, and firefighting.

MCHE 225 THERMODYNAMICS FOR CHEMICAL ENGINEERS (3Crs.: 3Lec, 0Lab): Heat and work, first law of thermodynamics, properties of steam and gases, steam tables and charts, entropy, second law, air standard cycle, compressors, reversibility, availability and second law efficiency, real gases. ***Pre-req.: PHYS 282*.**

MCHE 226 APPLIED THERMODYNAMICS FOR CHEMICAL ENGINEERS (3Crs.: 3Lec, 0Lab): Power and refrigeration cycles, vapor cycles, Carnot, Rankine, reheated, regenerative, gas power cycle, gas turbine, reciprocating engine cycles. Refrigeration and heat pump cycles, vapor compression cycle, absorption refrigeration cycle, thermodynamic tables. ***Pre-req.: MCHE 225*.**

MCHE 301 HVAC AND SANITATION FOR ARCHITECTS (2Crs.: 1Lec, 2Lab): This course addresses two technical fields, HVAC and Sanitation. HVAC: Introduction to air conditioning and mechanical installations in buildings and indoor spaces, general consideration, various heating and cooling systems, ventilation and air conditioning of various types, Installations and control of systems. Sanitation: Sanitary engineering issues, dampness: Sources and methods of insulation, water supply treatment and distribution, sanitary fixtures, installation and connections, treatment of soiled water, rainwater drainage and storm sewers.

MCHE 319 MECHANICS OF MATERIALS for PE (3Crs.: 3Lec, 0Lab): Introduction to the mechanics of deformable bodies considering linear material response. Load-stress, stress-strain, and strain-displacement relations. Tension/compression of rods and trusses, torsion of shafts, bending in beams, bucking of columns, and pressure vessels. Analysis of combined loading. Mohr circle analysis. Stress-strain transformations. Statically indeterminate structures. ***Pre-req.: CVLE 210*.**

MCHE 329 THERMODYNAMICS for PE (3Crs.: 3Lec, 0Lab): Introduction and basic concepts. Properties of pure substances. Energy analysis of closed systems. Mass and energy analysis of control volumes. Second law of Thermodynamics. Entropy, gas power cycle, vapor power cycle, vapor refrigeration cycle, real gas, Gas vapor mixtures and air conditioning. ***Pre-req.: PHYS 282.***

MCHE 338 PUMPS AND PIPING SYSTEMS (3Crs.: 3Lec, 0Lab): Pipeline and piping system, Pump types and operation, Centrifugal pumps operation, pump selection, pump in parallel and series, viscosity effect on centrifugal pumps, pump problem (Cavitation), priming of centrifugal pumps. ***Pre-req.: MCHE 331* and CHME 202.**

MCHE 339 FLUID MECHANICS for PE (3Crs.: 3Lec, 0Lab):): Introduction to Fluid Mechanics, Fluid properties, Fluid static, Forces on immersed surfaces, buoyancy and stability of floating bodies, fluid masses subjected to acceleration, vortex motion, hydrodynamics, Basic fluid dynamic equation, Continuity equation, Bernoulli's equation, fluid flow in pipelines, pipe losses, major and minor losses calculation, series and parallel pipes. Introduction to pumps. ***Pre-req.: PHYS 282*.**

MCHE 407 THERMAL AND HYDRO POWER STATIONS (3Crs.: 3Lec, 0Lab): Thermal Power Stations: Introduction to power generation; modern power plant layouts; gas fired, combined cycle; thermodynamic principles including Rankine cycle, Brayton cycle, and combined cycles; steam generations and boiler systems; steam turbines systems; condensers and cooling technologies. Energy conservation, continuity; introduction to fluid mechanics and hydraulic machines: pumps, turbines.