# Faculty of Engineering

# Department of Mechanical and Manufacturing Engineering

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INTRODUCTION

Mechanical and Manufacturing Engineering is a key discipline, that impacts on nearly every aspect of daily life, and is at the core of all technological developments.

The Department of Mechanical and Manufacturing Engineering (MME) was founded in 2001, and is one of the four departments in the Faculty of Engineering at the University of Cyprus. The first undergraduate students were admitted in September 2003 and graduated in June 2007. The first graduate students were admitted in January 2005. More than 200 undergraduate students and 60 graduate students, at Master and PhD level, are currently enrolled in the MME programme. Every year about 60 new students are admitted to the undergraduate programme.

The faculty of the Department consists of experienced and distinguished professors, with expertise in a wide range of research fields.

The Department offers a four-year undergraduate degree programme, which is designed based on international standards, as well as the peculiarities of the country, and places emphasis on cutting-edge technologies.

The Department’s curriculum and teaching methodology offer students an excellent education, while also cultivating their entrepreneurial spirit. The Department aims in producing graduates, who are well qualified and confident to promote innovative ideas, that will stimulate development of a new high-technology-based industry in Cyprus.

Research and innovation are encouraged in an environment that fosters cooperation among students, faculty, industry, and research organizations.

The Department offers: B.Sc. in Mechanical and Manufacturing Engineering and Minor in Biomedical Engineering.

## MECHANICAL AND MANUFACTURING ENGINEERING

Course hours/credits at the University of Cyprus follow the European Credit Transfer and Accumulation System, ECTS. Therefore, a B.Sc. degree in Mechanical and Manufacturing Engineering requires successful completion of a minimum of 240 ECTS, of which, 15 ECTS should be earned for elective courses (not included in the student's specialisation) from two different Faculties of the University, and 10 ECTS should be earned for English language courses.

The programme is designed to produce highly qualified graduates with a strong background in the fundamentals of the field, societal sensitivity and the independence of thought required for a successful career in Mechanical and Manufacturing Engineering. The curriculum follows a deductive approach to learning, which stems from the fact that all physical phenomena important to Mechanical and Manufacturing Engineers are governed by a set of simple physical laws. To meet an actual need posed by society, a successful mechanical engineer is expected to use these laws to describe the problem of interest and then use his/her experience to devise a solution. The solution is most often obtained through a combination of analytical, computational, and experimental means. Therefore, the curriculum educates students in basic physics, while reinforcing their mathematical skills and their ability to use computations and experimentation to obtain solutions at the stage of design.

An important goal of the Department’s educational system is to produce creative and entrepreneurial students, who will be willing to further develop their ideas into commercial products.

## FINAL YEAR PROJECT

This project is developed in the course of an entire year and is compulsory for all fourth-year Mechanical and Manufacturing Engineering students. The project may be a group or an individual one. The faculty members suggest interesting topics at the end of each semester, and students in consultation with their faculty advisors select one of them. The purpose of this project is for students to solve an interesting engineering problem, with a combination of analytical, computational and / or experimental means.

## AREAS OF CONCENTRATION

Students enrolled in the Mechanical and Manufacturing Engineering programme should take a minimum of 5 elective courses (30 ECTS) from the list of technical elective courses. Elective courses from the following areas are offered: Mechanical Engineering, Manufacturing Engineering, Biomedical and Engineering and Materials Science and Engineering.

## AREAS OF RESEARCH

Research in the Department of Mechanical and Manufacturing Engineering covers a wide range of fields such as:

- Biomedical Engineering
- Computational Mechanics
- Materials Science and Engineering
- Mechanical System Modelling and Controls

• Micro- and Nano-technology
• Robotics
• Thermofluid Mechanics and Energy Systems

## COURSE DESCRIPTIONS

**Compulsory Courses**

**MME 105 Experimental and Statistical Analysis I (5 ECTS)**

This experimental course aims to introduce the students to basic experimental techniques employed for the determination of physical parameters, to the statistical analysis of experimental data, graphical methods for data presentation and to the preparation of laboratory reports. Moreover, one of its primary objectives is to enable the students to make the transition from the physical principles they have been taught, to engineering notions. In addition, during this course the students attend a series of seminars including health and safety regulations in laboratories, technical report writing, introduction to library services, training on the use of the electronic library catalogue, information resources, and reference tools and a seminar related to plagiarism.

**Laboratory Exercises**

1. Law of conservation of linear momentum (Newton's $2^{nd}$ Law) and dynamics of rotation – gyroscope
2. Determination of friction coefficient
3. Spring Constitutive Law: Statics and Dynamics
4. Conservation of Energy: Torque – Work
5. Torque of Parallel and non-parallel forces
6. Moment of inertia
7. Thermal expansion and specific heat capacity
8. Gas Laws: Boyle's Law and Charles' Law
9. Determination of viscosity by falling sphere method
10. Measuring electrical quantities – Ohm's Law
11. DC motor and electric circuit
12. Study of flows around bodies (drag and lift measurements)
13. Buoyancy effects in immersed objects and density of a fluid - Archimede's principle

**MME 106 Introduction to Engineering (5 ECTS)**

Units and unit systems - Physical concepts such as forces, pressure, work, energy, temperature, heat – Newton's Laws – Motion – Inertial and Non-inertial Reference Frames – Work and Energy – Equilibrium – Energy conservation – Momentum conservation – Law of Gravity – States of Matter – Density and Pressure – Heat and Internal Energy – Heat Capacity and Specific Heat - The First Law of Thermodynamics. Introduction to the profession of the Mechanical Engineer through seminars from professional engineers working in various sectors of the Cypriot economy. The students have the opportunity to discuss on various issues at the end of each presentation.

**MME 107 Introduction to Electromagnetism (5 ECTS)**

The aim of the course is the comprehension of basic concepts and phenomena of Electromagnetism, and development of students' ability in solving problems using calculus. Particular emphasis is given to the relationship between the basic physical phenomena and their application in technology. Topics covered: Electric charge and matter; Electric field; Electrostatic potential; Capacitors and dielectrics; Electric current and resistance; DC circuits;

Magnetism; Magnetic fields; Ampere’s law; Faraday's law; Inductance and coils; Electromagnetic oscillations; AC circuits; Electromagnetic waves.

**MME 125 Statics (5 ECTS)**

Moment of a force about a point and a given axis – Replacement of a given system of forces by a simpler equivalent system - Equilibrium 3D problems of rigid bodies - Centroids and centers of gravity - Analysis of Structures – Trusses - Analysis of Trusses by the Method of Joints and Method of Sections – Frames - Equilibrium problems of rigid bodies including friction - Shear Force and Bending Moment – Calculate Moment of inertia of area and mass - Determine the moment of inertia of area and mass for composite bodies.

**MME 145 Computer Aided Drafting (5 ECTS)**

Engineers must be able to create and interpret detailed and assembled drawings in order to communicate their ideas. The course emphasizes on the connection between the drawings and three-dimensional geometric models of a product and its design and manufacturing processes. Topics taught include: international conventions and standards; drawing scales; drawing line types; projection planes; views and view layout; isometric views; auxiliary views; sections; three-dimensional geometric modeling. All topics are implemented through a team project that develops an integrated three-dimensional model of a mechanical device. Autodesk Mechanical and SolidWorks are the software used to create drawings and geometric models.

**MME 155 Material Science and Engineering I (5 ECTS)**

This course is the first part of the series “Materials Science and Engineering” and includes: Crystal structure; Unit cells – density – crystallographic directions and planes; Dislocations and Defects; Material microstructure; Diffusion – Elastic and Plastic Deformation; Stress vs Strain – Definition of Mechanical Properties (tensile strength, yield strength, Young modulus, Poisson ratio, ductility etc); Strengthening of metals (grain size, solid solutions, cold work); Failure of materials; Fatigue; Creep; Phase diagrams and phase transformations; Heat treatment of metals; Annealing; Precipitation Hardening; Characteristics of common alloys (i.e. perlite, benite, martensite, temper martensite), Processing and mechanical properties of metals and ceramics; Composite materials; Fiber Composites; Prediction of mechanical properties of composites made by known materials.

**MME 156 Chemistry for Engineers (5 ECTS)**

Atomic structure and chemical bonds. Chemical equations: Stoichiometry, moles, concentration, molarity, density etc. Chemical reactions between acids and bases; chemical reactions involving gases; combustion reactions. Redox reactions. Examples: electrolysis, corrosion, fuel cells, etc. Chemical Thermodynamics and Thermochemistry. Equilibrium: Equilibrium in physical processes, characteristics of a dynamic equilibrium, equilibrium in chemical reactions, equilibrium constant and equilibrium Law, parameters influencing the chemical equilibrium. Strength of acids and bases: The meaning of pH. Special topics: Polymers and Advanced materials and nanotechnology.

**MME 208 Programming and Numerical Methods (5 ECTS)**

**Prerequisites: MAS 029**

This course concerns teaching the basic principles in computer programming and numerical methods. Through MATLAB, the students will be taught a wide range of topics in numerical methods and analysis in linear algebra, developing graphs and plots, root finding, numerical solution of linear and non-linear systems, interpolation and approximation methods, numerical integration and differentiation, complex numeric algebra, and an introduction using symbolic algebra. Also, a brief introduction programming with FORTRAN will be carried out. This includes teaching material in basic syntax rules and coding in FORTRAN (program structure, basic data types, arrays, variables read/write, etc.) as well as coding subroutines and functions.

**MME 215 Thermodynamics I (5 ECTS)**

Units, dimensions and measurements; basic properties (pressure, temperature); equation of state for perfect gas; calorimetry; specific heat capacities; energy, internal energy, heat, work, entropy. Conservations laws in closed (control mass) and open (control volume) systems. 1st and 2nd law of thermodynamics, implications. Thermodynamic phase diagrams & process paths. Cyclic thermodynamic processes, isothermal, adiabatic and polytropic processes. Thermodynamic cycles and efficiency. Vapour and gas-power cycles, Carnot cycle, Diesel & Otto cycles. Real substances, properties of steam. Basic computational simulation tools.

**MME 216 Incompressible Fluid Mechanics I (5 ECTS)**

**Prerequisites: MAS 025**

Introduction to principal concepts and methods of fluid mechanics. Description of Fluids and their properties (density, viscosity, surface tension). Fluid statics: manometry, pressure, hydrostatics and buoyancy. Forces on submerged surfaces. Fluid shear and viscosity, Newtonian and non-Newtonian fluids. Open systems and control volume analysis; mass conservation, momentum and energy conservation for moving fluids. The Bernoulli equation & practical applications. Hydraulic jumps and waves in fluids. Differential fluid flow analysis, Continuity (mass conservation) and Navier-Stokes equation (momentum conservation); analytical solutions. Viscous fluid flows in pipes: Laminar, transitional and turbulent flows. Re-scaling and; boundary layers. External and internal flows. Forces on bodies, lift and drag. introduction to flow measurement techniques (pitot, orifice plate, Venturi etc).

Laboratory Exercises

- Flow visualization
- Manometry and Bernoulli’s principle
- Drag and lift around bodies (assignment, they print bodies) in a wind tunnel
- Pipe Flow: frictional losses in pipes
- Introduction to Flow metering techniques (manometers, pitot, Venturi, orifice)

**MME 217 Heat Transfer (5 ECTS)**

**Prerequisites: MAS 025**

Linear and volumetric expansion. Mechanisms of Heat Transfer (HT), Fourier, Newton and thermal radiation laws of HT. Conductivity and diffusion coefficients, emissivity. Electrical analog of HT, electrical resistance and equivalent thermal circuits. General differential equation of heat conservation. Steady conduction in one dimension with or without internal heat sources, analytical solutions of flat walls, cylinders and spheres. Steady conduction in two dimensions, shape factors, numerical solutions. HT from fins and extended surfaces. Transient HT, Heisler charts. Lumped capacitance method, Biot and Fourier numbers. Forced and natural convection, Reynolds, Prandtl, Nusselt, Rayleigh and Grashof dimensionless numbers. Mixed convection, boiling and condensation. Heat exchangers.

**Laboratory Exercises**

- Measurement of thermal conductivity
- Measurement of coefficient of emissivity
- Effect of distance on thermal radiation
- Laboratory assignment in Matlab
- Laboratory assignment in SolidWorks

**MME 225 Dynamics (5 ECTS)**

**Prerequisites: MME 125**

The course introduces the student to the fundamental principles of dynamics and their application in the analysis of motion of particles and rigid bodies in two and three dimensions. Topics covered: (a) kinematics of particles, (b) kinetics of particles (Newton's second law, D'Alembert's principle and dynamic equilibrium, methods of energy and momentum), (c) impact: direct central impact; oblique central impact, (d) kinematics of rigid bodies, (e) planar kinetics of rigid bodies (forces and acceleration, planar motion, energy and momentum methods), and (f) introduction to the dynamics of rigid bodies in three dimensions.

**Laboratory Exercises**

- Study of mass moment of inertia and angular acceleration
- Study of centrifugal force on rotating masses
- Study of Coriolis force in rotating reference systems.

**MME 226-Mechatronics I (5 ECTS)**

**Prerequisites: MME 107, MME105**

Circuit elements, waveforms, DC and AC circuits including RLC, complex notation. Thevenin and Norton theorem, maximum power transfer theorem, power and power factor, transformers. Also, semiconductors, diodes, transistors, types and operation, rectifiers, photodiodes. Operational amplifiers, inverting, non-inverting, sum and difference, integrator, differentiator, buffer amplifiers. Digital electronics, binary arithmetic, logic gates NOT, OR, AND, NOR, NAND, XOR truth tables and circuits. Half/full adders. Introduction to sensors and actuators. The course also includes three lab sessions on circuits including passive and active elements thereby extending the skills and knowledge of students which were acquired in MME 105 on how to use multi meters, oscilloscopes, and waveform generators to build and analyze circuits.

**Laboratory Exercises**

- Half and full wave rectifier
- RLC circuits
- Transformers
- RLC-DC circuits
- RLC-AC circuits
- Digital circuits and logic gates.

**MME 227 Vibrations (5 ECTS)**

**Prerequisites: MAS 025, MME 225**

This is an introductory course on mechanical vibrations. One degree of freedom systems are used to explain: (a) the basic principles of modelling, (b) the second order differential equations that modelling yields, and (c) the relationship between the system physical parameters and the differential equations. The notions of (un)damped natural frequency and resonance are defined using the system parameters and their real-life importance is thoroughly discussed. Two degree of freedom systems are studied in order to define the concept of mode shape. Computation of mode shapes and natural frequencies of two degree of freedom systems. Computation of the frequency response function of forced two degree of freedom systems.

**Laboratory Exercises**

- Responses of free undamped and damped systems
- Free bending vibration and natural frequency determination
- Forced vibration and experimental determination of frequency response functions

**MME 228 Mechatronics II (5 ECTS)**

**Prerequisites: MME 226**

The first half of Mechatronics II is focused on LabView which will be taught in a computer lab. It will cover basics aspects of LabView such as the front panel, block diagram, numeric types, logical variables and operations, strings, arrays, matrices, graphs, controls, indicators, timing, structure, while and for lops, conditionals, data acquisition, signal processing and control. Students will be evaluated by programming exercises. During the second half the basic background notions of electrical motors will be introduced: magnetic circuits, energy conversion, torque production and motor drives. These notions will be used to understand the operation of DC, brushless DC, stepper and servo motors. Laboratory exercises using various types of DC electric motors are included.

**Laboratory Exercises**

- Familiarization with the front panel and block diagram environment of LabView
- Manipulation and interconversion of numeric types, logic variables and operations
- Introduction to strings, arrays matrices
- Timing and timers, indicators and controls
- Iteration control and conditionals
- Data acquisition and signal processing
- Dynamic analysis and parameter identification of DC, brushless DC, stepper, servo motors
- Design and implementation of motor drive.

**MME 255 Materials Science and Engineering II (5 ECTS)**

**Prerequisites: MME 155**

This course is the second part of the series "Materials Science and Engineering". The first part of the course focuses on the thermal, electrical, magnetic and optical properties of metals, ceramics and polymers. The last part of the course discusses both how to select materials for engineering applications and the economic, environmental and social issues related to the science and technology of materials.

**MME256-Solid Mechanics (5 ECTS)**

**Prerequisites: MME125**

The material being taught in this course covers the introduction and theoretical description of the fundamental notions in solid mechanics (stress and strain measures, stiffness, etc.), generalized theory of elasticity (Hooke's law), Mohr's circle (in 2D and in 3D), uniaxial stress analysis (tension, compression), uniform loading of plates, (elastic and elastoplastic) shaft torsion, (elastic and elastoplastic) beam bending and eccentric beam loading.

The course also contains laboratory sessions that are supported by hands-on lab work and experiments of the following tests:

tensile test (of ductile and brittle metals),
compression test,
three-point bending test, and hardness test (Rockwell, Vickers).

**MME 257 Strength of Materials (5 ECTS)**

**Prerequisites: MME 256**

The material being taught in this course extends from MME256 and covers course material related to the evaluation of stress concentrations and residual stresses, stress evaluation in composite members and structures, flexural loading of beams and shafts, buckling of slender bodies and structures, uniform loading of metallic plates, shells and pressure vessels, and a brief outline of the energy theorems and methods, and the failure criteria involved in (elastic-perfectly plastic) metals, ceramic, polymers and fibrous materials.

**MME 315 Thermodynamics II (6 ECTS)**

**Prerequisites: MME 215, MAS025**

Behaviour and properties of non-reacting mixtures with emphasis on mixtures of ideal gases. Psychrometric analysis of air-conditioning systems. Origin of irreversibilities & entropy, properties of liquids and gases, process and cycle representation on T-s and h-s chart. Turbines, compressors and isentropic efficiency. Simple steam and gas turbine cycles (Rankine and Brayton), refrigeration cycles, combined cycles. Introduction to the thermodynamics of compressible flows: steady isentropic flows with choking, shock waves, convergent-divergent passages, compressibility effects with friction and heat transfer. Design of thermodynamic systems using computer software.

**Laboratory Exercises**

- Design competition for the optimization of a thermodynamic system using computer software.
- Thermodynamics of the refrigeration circuit
- Vapor pressure of water Boiling process
- Heat pump for cooling / heating operation

**MME 316 Incompressible Fluid Mechanics II (6 ECTS)**

**Prerequisites: MME 216**

Frictional flow resistance in single pipes and pipe networks, Moody diagram. Local losses and friction factors in fittings. losses in series, energy line and hydraulic gradient. Darcy-Weisbach equation, friction factors for laminar and turbulent pipe flows. Dimensional analysis and similarity, scale modelling. Low and high-speed aerodynamics. Boundary layers, Blasius solutions and separation. Compressible flows, Subsonic, sonic, supersonic and hypersonic flows, shock waves, connection with thermodynamics. Introduction to turbulent flows, transition criteria and turbulence modelling. Fluid Machinery: Turbomachinery: conservation of angular momentum, principles of energy exchange, machine losses and characteristics; fluid pumps and fans operating point; non-dimensional groups. Cavitation. Experimental techniques in fluid dynamics.

**Laboratory Exercises**

- Hydraulic gradient in a pipe network
- Pump performance & operational envelopes
- Experimental techniques in fluid dynamics (measurement in a BL with hot wires, pitot tubes, venture meters)

**MME 307 Numerical Methods (6 ECTS)**

**Prerequisites: MME 208**

This course is an introduction to numerical methods for the solution of real engineering problems. Topics covered include numerical integration and optimization and solution of ordinary and partial differential equations (ODEs and PDEs). Methods that are used for the solution of ODEs include the Implicit and Explicit Euler method, the Runge-Kutta methods and the Adams-Bashforth-Moulton methods. The solution of PDEs is performed with the finite difference method in one and two-dimensions. Both steady state and time-dependent problems are solved. The course also covers a brief introduction to the finite element method. It includes a programming component for writing algorithms for the numerical solutions in FORTRAN and Matlab.

**MMK318 Thermal Engines (6 ECTS)**

**Prerequisites: MME 315**

Types, technologies and classification of thermal engines, thermodynamic cycles and performance Internal Combustion Engines (ICE), kinematics. Thermodynamic cycles and performance metrics. Timing, two-stroke and four-stroke ICE. Operating principles of Otto, Diesel, HCCI and gas turbines. Combustion of gas mixtures. Theoretical and actual cycles of reciprocating engines and gas turbines. Energy balance. Heat transfer, lubrication and cooling. Special conditions and problems of combustion of various fuels. Mixture Formation, load settings. Configuration of the combustion chambers and fuel injection. Pollutants & emissions. Turbocharging and supercharging. The course includes a series of laboratory exercises.

**Laboratory Exercises**

- Disassembly and assembly of an ICE engine
- Torque and power output of a petrol engine
- Emissions experiment using a diesel engine
- PV diagram of a diesel engine

**MME 325 Modeling and Analysis of Dynamic Systems (6 ECTS)**

**Prerequisites: MAS 027, MME 225**

The course introduces a unified approach for modeling real dynamic systems. Modeling is accomplished using appropriate graphical or state-space equation models, in order to meet the requirements during the use of the models in design and automatic control. System analysis is used to calculate behavioral characteristics and to evaluate the accuracy of modeling assumptions. Topics taught include lumped parameter models; models with electric, fluid and thermal elements; interfaces; state-space equations; block diagrams; Laplace transforms – transfer functions; time and frequency domain response; stability. Students use Matlab/Simulink as a computational analysis tool. Laboratory exercises are used to identify parameters and demonstrate the interaction between different physical phenomena.

**MME 327 Control Engineering (6 ECTS)**

**Prerequisites: MME 325**

The course introduces students to feedback control systems and the classical control theory. Topics covered: (a) History of control and modern applications. (b) Use of dynamical system modeling (mathematical models, Laplace transform, transfer function, block diagrams, system response) in the design of control systems. (c) Feedback control setup and characteristics. (d) Time-domain specifications. (e) System stability and the Routh-Hurwitz criterion. (f) Feedback properties and simple controllers including the PID controller. (g) Steady-state analysis, system type and error constants. (g) Root locus analysis and design. (h) Frequency response design and analysis using Bode plots and Nyquist plots.

**Laboratory Exercises**

- Rotary flexible joint / flexible link arm control
- Linear / rotary servo inverted pendulum control

**MME 345 Machine Elements (6 ECTS)**

**Prerequisite: MME 257**

The course will teach methods for the calculation, selection and use of components (machine elements) required in mechanical engineering. The course first introduces engineering design principles, while also reinforcing students' understanding of material properties, load and stress analysis, deformation and elasticity, and theories of material failure. Subsequently, the main machine elements, their properties and selection procedure are defined. The machine elements studied include: shafts; screws/nonpermanent joints; welding/permanent joints; springs; roller/journal bearings, gears. The course includes a team project to design an engineering device and create its 3D geometric model on a computer.

**Laboratory Exercises:** Experimental setups for hands-on experience and demonstrations of the machine elements taught in this course

**MME 346 Mechanical Design (6 ECTS)**

**Prerequisite: MME 345**

This is a two-part course on machine elements and design. The topics of the machine elements part of the course are: gears and power transmission, strength of gears, principles of operation of clutches and brakes, and the theory of flexible machine elements such as belts and chains.  In the design part of the course the design process will be discussed in detail· starting from design brief preparation, to the generation of ideas and concepts that could satisfy the need as described in the design brief and ending with the materialisation of the final product.

**MME 347 Design and Manufacturing (6 ECTS)**

**Prerequisites: MME 145**

Introduction to modern Computer-aided Design and Manufacturing Technology, with emphasis on geometrical aspects (material aspects are covered in MME348). Design by CAD, representation of 2D/3D lines, surfaces and objects, geometric processing by homogeneous transformations. Rapid prototyping with material deposition - technologies, systems and applications. Machining processes, material removal, non-traditional technologies, manufacturing by CAM. Shaping by deformation/flow of foil and bulk material, CAE analysis. Surface patterning by lithography, coating and etching, micro- and nanotechnology. Metrology, microscopy, scanning and machine vision, instruments and image processing. Tolerances, fits, surface quality and defects. Assembly and transportation with automation, robotics and navigation systems. Applications of design and manufacturing systems.

**MME 348 Manufacturing Processes (6 ECTS)**

**Prerequisites: MME 347**

This course will take a broad look at the various manufacturing processes for available engineering materials. The lecture material will be reinforced by laboratory sessions and problem sets. Topics covered include: Introduction to manufacturing processes for engineering materials; Review of fundamental mechanics of plastic deformation; Structure and manufacturing properties of metals; Surface structure, treatments and tribology; Metal-casting and heat treatment processes; Bulk deformation processes: turning, milling, drilling, etc.; Material removal processes: abrasive, chemical, electrical and high-energy beams; Joining processes: soldering, brazing, welding, etc.; Micro- and nanofabrication.

**MME 405 Final Year Project I (7 ECTS)**

The project is developed over the course of an entire year and is compulsory for all fourth-year Mechanical and Manufacturing Engineering students. The project may be a group or an individual one. Faculty members suggest topics from which students, in consultation with their chosen advisors, make their selection. The purpose of this project is for students to solve an interesting engineering problem, with a combination of analytical, computational and / or experimental means.

**MME 406 Final Year Project II (8 ECTS)**

Prerequisites: MME 405

Continuation of the course "Final Year Project I"

## Technical Elective Courses

**MME 416 Refrigeration, Heating, and Air-conditioning (6 ECTS)**

**Prerequisites: MME 217, MME 315**

Analysis and design of Air-conditioning Systems for maintaining comfort conditions in spaces of small and large buildings. Analysis of Refrigeration Systems for industrial and other applications. Climatological Data and comfort conditions; Psychrometry; Solar Loads; Air-conditioning loads; Loads of Walls, Class Windows, Lighting, Human Heat, Devices; Refrigerants; Basic Refrigeration Cycles; Air Conditioning System: fan-coil units, air (variable flow or temperature), water/air, heat pump; Legislation

**MMK 417 Energy Systems (6 ECTS)**

**Prerequisites: MME 315**

Energy and power, energy balance, conversion efficiency. Conventional, renewable energy sources. Steam & gas turbines, Electric Motors, Generators. Cogeneration. Thermoelectrics and applications, fuel cells, operating principle and types, hydrogen as a fuel. Solar Energy and calculation of solar potential, solar geometry. Solar thermal systems. Photovoltaics, formulas, curves and operating performance. Wind energy and wind power, wind turbines, wind farms. Hydro energy. Biomass, Biogas. Geothermal, wave energy and marine currents. The course includes laboratory exercises

**MME418- Compressible Flow (6 ECTS)**

**Prerequisites: MME215, MME315, MME307**

Compressible gas flow is a topic of interest in contemporary engineering applications, such as the transport and storage of natural gas. This course is an introduction to the fundamentals of the compressible flow of gases and includes the following topics: appropriate conservation laws; propagation of disturbances; isentropic flows; Mach number, speed of sound and regimes in compressible flow; one-dimensional steady compressible flow; choking in isentropic flow; isentropic flow in convergent-divergent passages; normal shock wave relations, oblique shock waves, weak and strong shocks, and shock wave structure; compressible flows in ducts with area changes, friction, or heat addition; Prandtl-Meyer function. The emphasis will be on physical understanding of the phenomena and basic analytical techniques.

**MME419- Modern Computational Tools For Engineers (6 ECTS)**

**Prerequisites: MME208, MME307**

Computational engineering refers to the process of translating the description of physical systems into models that can be analyzed using computers. The use of computational tools for analysis is part of the everyday routine of engineers. When properly used computational tools are a powerful ally that every engineer should be able to rely on. This course offers an introduction to *Object Oriented Scientific Programming* (OOSP) as a paradigm for the design and development of effective scientific programs. Emphasis is placed on the tremendous capabilities unleashed in Fortran 2008/2015, which allows parallel programs to be developed and executed on personal computers with minimal overhead. The process of modeling of physical systems and the subsequent program design and development are treated as a unified process. Programming skills are developed through a series of examples from various branches of Mechanical Engineering, such as fluid dynamics, energy storage conversion and transfer, and biomedical engineering.

**MME420- Robotics (6 ECTS)**

**Prerequisites: MME327**

The course introduces the students to the field of robotics with emphasis on robotic manipulators. Applications, theoretical analysis, design, and control issues are considered. Topics covered: (a) History, types of robotic systems and applications, (b) Terminology, main parts, kinematic chain, end-effectors, (c) Coordinate transformations, rotation matrices, and homogeneous transformations, (d) Forward kinematics analysis, Denavit-Hartenberg procedure, inverse manipulator kinematics, (e) Velocity kinematics, Jacobian matrix, inverse velocity kinematics, singular configurations, (f) Dynamics modeling, the method of Newton-Euler and the method of Lagrange, equations of motion, (g) Feedback control schemes, trajectory planning, (h) Sensors and actuators used in robotics, (i) Specifications of industrial robotic systems and safety measures.

**Laboratory Exercises**

- Motion planning and programming of basic pick-and-place tasks
- Industrial application simulation using a belt conveyor

**MME421- Advanced Dynamics and Applications (6 ECTS)**

**Prerequisites: MME225**

The course focuses on the motion of rigid bodies in three-dimensional space. Kinematics and dynamics of rigid bodies are studied in order to derive the equations of motion using various modern approaches. Topics taught include inertia properties and angular velocity; Newton-Euler equations of motion; degrees-of-freedom and constraints; kinetic/potential energy and virtual work; Lagrange's equations for holonomic systems; numerical analysis of derived equations of motion. The formulations are applied to various multi-body dynamics problems that arise in mechanical and aerospace engineering, and the special case of planar mechanisms is also studied. Students use generalized and specialized software, like Matlab and SolidWorks, to analyze rigid-body systems.

**MME 426 Vibrations Theory and Applications (6 ECTS)**

**Prerequisite: MME 227**

This course studies the vibrations of linear systems consisting of finite multiple and infinite degrees of freedom. The theory of vibration absorption as generated by the basic theory of linear multi-degree of freedom systems is analyzed in its full detail. The partial differential equations describing the behavior of infinite degree of freedom systems are derived from the basic principles of strength of materials. The distinctive qualitative and quantitative characteristics of non-linear systems are described and subsequently and subsequently the methodology of extracting them for simple non-linear systems is presented. Topics studied: structure of dynamics and dynamical examples from various scientific disciplines, generalized coordinates, vibrations of multi-degree and infinite degree of freedom systems, non-linear system behaviour characterization: limit cycles, bifurcations and chaos.

**MME 436 Cell and Tissue Mechanics (6 ECTS)**

The aim of the course involves the study of the mechanical behavior of native human tissues, and how their mechanical properties are related to tissue function and pathology. Basic knowledge of mechanics (stresses, deformations, balance laws) will be employed to study the mechanical response of tissues such as arteries, heart valve leaflets, muscle tissue and bones. Subsequently, we will show how changes in the mechanical properties of these tissues can lead to diseases such as hypertension, and arteriosclerotic plaques. The course does not require knowledge of biology.

**MME442- Lasers and their Applications (6 ECTS)**

**Prerequisite: MME347, MME348**

Lasers are part of everyday tasks, such as reading grocery prices and printing or copying paper documents. This course emphasizes on the innovative use of lasers in manufacturing and material processing. Topics covered include: Laser background and general applications; Additive manufacturing (selective laser melting and sintering, manufacturing of multi-materials); Laser joining (welding of metals and plastics); Laser surface processing and modifications (texturing and coating deposition, and general surface processing and modification applications); Micro-manufacturing (laser cutting, drilling and welding for automotive, medical and other applications). The lecture material will be reinforced by laboratory sessions and problem sets.

**Laboratory Exercises**

- Laser marking and cutting
- Laser scanning
- Laser surface measurements and modifications
- Laser welding.

MME443- **Advanced Metal Working Processes** (6 ECTS)

**Prerequisite: MME347, MME348**

Manufacturing technologies are used to produce components of various shapes and sizes. This course focuses on manufacturing technologies commonly used by industry, with the focus on forging and sheet metal forming. The topics covered in the course include: scientific understanding of cold, warm and hot forging and cold and warm sheet metal forming processes, component and tooling design principles to maximize mechanical performance of produced components, modelling theory and analytical analysis of material behavior under cold, warm and hot operations, innovations in metal forming to maximize component performance.

**Laboratory Exercises**

- Cold and hot forging
- Material strengthening
- Sheet blanking, bending and forming

**MME451- Linear Static and Dynamic Finite Element Analysis of Solids**

**Prerequisite: MME307, MME257**

The material of this rather introductory course in finite elements identifies two major parts: (a) the simulation and analysis of linear elastostatic boundary value problems, in two and three dimensions respectively, and (b) the modelling of transient (time-dependent) solid mechanics problems and the modal finite element analysis of structures. In summary, this course covers essential material in computational solid mechanics using FEM for final year undergraduates and postgraduates in mechanical engineering, bioengineering and civil engineering. Students will also receive hands-on training on commercially available finite element software through laboratory workshops. Throughout these workshops, the students will develop representative 3D FEM models to simulate quasi-static and transient problems in linear elasticity.

The course also contains laboratory sessions to provide hands-on experience to the students in ABAQUS:

- Introduction to the graphical user interface of the software,
- design and analysis of a 3D truss problem / network,
- design and analysis of a plane stress problem,
- design and analysis of a quasi-static elasticity problem in 3D,
- design and analysis of a transient elasticity problem in 3D,
- FE analysis and evaluation of eigenmodes / eigenfrequencies.

**MME 456 Properties of Polymers and Polymer Processing (6 ECTS)**

**Prerequisite: MME 155**

The course is divided into two parts. In the first part, the mechanical properties of polymers (e.g., elasticity, viscoelasticity, strength, etc.) and the effect of their structural and chemical characteristics on their mechanical behavior are discussed. The structure-properties correlation, the thermal transitions of polymers and how these are capable of affecting their properties, as well as the rheological characteristics of polymeric solutions and melts are analyzed. In the second part, different methods used in polymer processing such as mixing, reinforcement, molding, etc. are discussed. Moreover the students are involved in laboratory demonstrations and exercises including the synthesis of physically-crosslinked polymer networks having variable crosslinking density, the fabrication of polymer nano/micro fibers by electrospinning and the determination of the thermomechanical properties of polymers by Dynamic mechanical analysis.

**MME 457 Material Measurements and Testing (6 ECTS)**

Measurements methodology. Metrology. Quality in measurements and testing. Reference materials. Accreditation. Measurements of mechanical properties - elasticity, plasticity, hardness, strength, fracture – standards – applications – limitations. Measurements of thermal properties - thermal conductivity, heat capacity, enthalpy, thermal expansions – standards – applications – limitations. Measurements of electrical properties - electrical conductivity, measurements in metals and semiconductors – standards – applications – limitations. Nondestructive testing and reliability evaluation – standards – applications – limitations. Materials testing for corrosion – standards – applications – limitations. Materials testing for friction and wear – standards – applications – limitations. The course includes labs on selected techniques.

**MME 458 Materials for Energy and Environment (6 ECTS)**

**Prerequisites: MME 255**

The course addresses questions such as: How will we meet rising energy demands? What are our options? Are there viable long-term solutions for the future? In addition, the course introduces the students to the fundamental materials science at the heart of: Renewable energy sources, Nonrenewable energy sources, Future transportation systems, Energy efficiency, Energy storage and, $CO_2$ capture and storage

**MME459- Composite Materials Science and Engineering (6 ECTS)**

**Prerequisites: MME155, MME156**

Length scales, dimensionality, three, two, one and zero dimensional materials. Definition of nano, meso and macro scales. One dimensional materials : fibers, nanowires, nanorods, nanotubes; organic and inorganic e.g. carbon, polymethylmethacrylate etc. Methods of production. Ordered versus disordered networks of one dimensional materials. Assembly, self-assembly, bottom-up versus top down approaches. Fabrication methods of ordered networks and additive manufacturing. Matrix materials e.g. metal, polymers etc. Prepreg composites. Naturally occurring fiber materials e.g. balsa wood, spider silk and their applications. Engineering applications, aerospace, marine, automotive, energy related.