

SYLLABUS FOR THE DEGREE OF MASTER OF SCIENCE IN ENGINEERING IN MECHANICAL ENGINEERING MSC(ENG)(ME)

[This syllabus is applicable to students admitted to the curriculum in the academic year 2016-17]

Definition and Terminology

Discipline course – any course on a list of courses in the discipline of curriculum which a candidate must pass at least a certain number of credits as specified in the Regulations.

Elective course – any course offered by the Departments of the Faculty of Engineering for the fulfilment of the curriculum requirements of the degree of MSc(Eng) in Mechanical Engineering that are not classified as discipline courses.

Capstone Experience# – a 24-credit dissertation which is a compulsory and integral part of the curriculum.

Curriculum Structure

Candidates are required to complete 72 credits of courses as set out below, normally over one academic year of full-time study or two academic years of part-time study:

Course Category	No. of Credits
Discipline Courses	Not less than 30
Elective Courses	Not more than 18
Capstone Experience#	24
Total	72

The curriculum provides advanced postgraduate education in the fields of energy and power; environmental engineering; material technology; theoretical mechanics and computer integrated design and manufacturing to graduates in engineering or related science.

Candidates shall select courses in accordance with the regulations of the degree. Candidates must complete 8 courses, including at least 3 courses from List A, and a dissertation. They may select no more than 3 courses offered by other taught postgraduate curricula in the Faculty of Engineering as electives. All course selection will be subject to approval by the Course Coordinators.

The following is a list of discipline courses offered by the Department of Mechanical Engineering. The list below is not final and some courses may not be offered every year.

All courses are assessed through examination and / or coursework assessment, the weightings of which are subject to approval by the Board of Examiners.

Special approval has been given by the Senate for candidates admitted to the part-time mode of the curriculum in the academic year 2016-17 to take additional discipline courses of the same credit value in lieu of the capstone experience to satisfy the curriculum requirements.

List A discipline courses

MECH6010. Service behaviour of materials (6 credits)

The aims of this course are: (1) to study the relevant physical basis for the understanding and prediction of the service behaviour, such as creep, fracture, fatigue and corrosion, of materials in industrial applications; and (2) to provide the knowledge to engineers the microstructure in such a way that the service behaviour of materials can be improved.

Topics include: creep regimes; creep mechanisms; creep resistant alloys; brittle fracture; ductile fracture; brittle-ductile transition; fracture mechanism maps; fatigue; Basquins and Coffin-Manson Laws; Goodman's relation; Palmgren-Miner rule; corrosion; electrochemical principles; forms of corrosion; corrosion control; case studies; service behaviour of engineering plastics; polymer-matrix composites.

MECH6026. Computational fluid dynamics (6 credits)

This course aims to provide practicing engineers and researchers who are learning about Computational Fluid Dynamics (CFD) for the first time with the basic knowledge of numerical techniques and applications of CFD to solve engineering problems.

Topics include: fundamental concepts and equations of fluid dynamics; finite-difference method for solving partial differential equations (stability, consistency, convergence, accuracy and efficiency, and solution of system of algebraic equations); simplified models for fluid flow (wave equation) and heat transfer (heat equation); grid generation; turbulent diffusion and shear flow dispersion; numerical solution of transport equations (mass; momentum and energy transport); applications involving the built environment, air pollution, atmospheric diffusion and dissipation, power-plant design, land-air-and marine-vehicle design; etc.

MECH6034. Computer-aided product development (CAPD) (6 credits)

This course will focus on main technologies related to computer-aided product development, including popular product development methodologies, computer-aided design, haptic shape modelling, reverse engineering, additive manufacturing and rapid tooling. The specific course objectives are: (1) To have a good understanding of popular product development methodologies, product development processes; (2) to understand major technologies that can be used to assist product development at different phases; (3) to be able to apply the computer-aided product development technologies to develop a simple product; and (4) to understand the constraints of manufacturing and cost in product development.

Topics include: product development methodologies; basic product manufacturing technologies; design for manufacturing; product costing and value engineering; solid modelling techniques; reverse engineering; additive manufacturing.

MECH6047. Finite element analysis in mechanics (6 credits)

This course aims to: (1) introduce the basic concepts and procedures in finite element analysis; (2) introduce the methods of analysis using the finite element method for mechanics problems in engineering; and (3) provide hands-on experience on conducting various mechanics analyses by using a state-of-the-art finite element software.

Topics include: concepts and procedures in finite element analysis; elasticity analysis of truss, beam,

plane and plate problems; thermo-mechanical analysis; direct integration methods for dynamic analysis; geometric and material nonlinear analyses; contact analysis; hands-on experience of finite element analysis.

For students taking the course in the academic year 2017-18 and thereafter:

This course aims to: (1) introduce the basic concepts and procedures in finite element analysis; (2) introduce the methods of analysis using the finite element method for mechanics problems in engineering; and (3) provide hands-on experience on conducting various mechanics analyses by using a state-of-the-art finite element software.

Topics include: concepts and procedures in finite element analysis; elasticity analysis of truss, beam, plane and plate problems; thermo-mechanical analysis; modal analysis; direct integration methods for dynamic analysis; geometric and material nonlinear analyses; contact analysis; hands-on experience of finite element analysis.

MECH7011. Applied thermodynamics and power plant technology (6 credits)

This course is focused on understanding the operating principles of power plants for the generation of electric power. The course objectives are to: (1) provide students with the working principles of various types of power plants, including fossil fuels, nuclear fuels and renewable energy; and (2) enable students to understand the thermodynamic principles, emission controls, environmental impact, cycle analysis, component design, plant operation and control technologies of power plant.

Topics include: sources of energy; thermodynamic properties of states; types of power plants; portable combustion engines; Brayton cycle; gas turbines; Rankine cycle; steam power plants; nuclear power plant; solar farm; wind turbines; thermoelectric energy.

Students who have taken and passed MECH6023 will not be allowed to take MECH7011.

List B discipline courses

MECH6017. Noise and vibration (6 credits)

This course aims to provide an integrated treatment for vibration system, noise radiation and the available control methods in engineering. Upon completing this course, the students are expected to: (1) explain the basic characteristics of a simple vibration system; (2) understand the mechanism of noise radiation by structural vibration or turbulent flow, and its impact on human hearing; and (3) offer solution to typical noise and vibration problems. The following are covered in the course: (i) fundamentals of vibration and its control, (ii) human hearing and environmental noise sources and their mitigation, (iii) noise control.

Topics include: fundamentals of single- and multiple degree of freedom systems; vibration modes and finite element analyses; vibration measurement; vibration isolation; sound radiation by vibration and flow; human hearing; environmental legislation and guidelines; sound propagation and duct acoustics; noise absorption and reflection; control of noise at the source.

MECH6018. Atmospheric environment modelling (6 credits)

This course aims to: (1) provide rigorous and comprehensive treatment of various modelling methodologies on the atmospheric environment and air pollution dispersion; and (2) introduce the state-of-the-art of various modelling packages for use in industry.

Topics include: foundations of atmospheric dynamics, models of winds, atmospheric turbulence modelling, boundary layer climate, air pollution in the boundary layer and atmospheric dispersion modelling.

MECH6019. Sources and control of air pollution (6 credits)

This course aims to: (1) provide understanding of the natural and anthropogenic sources of air pollution; and (2) introduce ways to prevent, control and minimize pollution by application of various control practices.

Topics include: concepts and procedures in basis of air pollution, air pollutant transport, sources of air pollutants, control of gaseous pollutants, control of particulate matter, atmospheric dispersion modelling.

MECH6024. Applied mathematics for engineers (6 credits)

This course aims to introduce some advanced knowledge of computational and statistical analysis and methods and provide the students with the ability to apply computational and statistical methods to solve engineering problems.

Topics include: statistical and numerical methods in engineering; hypothesis testing; estimation of parameters and confidence intervals; correlation coefficient; direct and iterative methods for systems of equations; optimization; numerical analysis.

EMEE6004. Energy conservation and management (6 credits)

This course aims to: (1) understand the technological, social, economic and environmental factors related to the use of fossil fuels and renewable energy; (2) understand the major energy consumers in buildings, transportation and industrial processes; and (3) identify effective energy conservation and conduct energy audits and management systems.

Topics include: energy sources and environmental impact; energy in buildings; energy-efficient industrial processes; waste heat recovery; energy storage; energy auditing; energy strategies and management.

Students who have taken and passed MECH6033 will not be allowed to take EMEE6004.

MECH6039. Biomaterials and tissue engineering (6 credits)

This course aims to: (1) equip students with a broad knowledge of biomaterials science and engineering and also tissue engineering; (2) have an in-depth understanding of various types of biomaterials currently in clinical use; (3) learn various techniques for developing, analysing and testing new biomaterials; and (4) make students aware of prosthetic medical device regulations and standards for materials and devices; to learn the most recent developments in the biomaterials and tissue engineering field and also future trends.

Topics include: definitions and fundamentals in biomaterials science and engineering; classification for biomaterials; criteria for biomaterials; bioceramics; metallic biomaterials; bioactive ceramic coatings; biomedical polymers; biomedical composites; analytical and testing techniques for developing new biomaterials; long-term performance of biomaterials; degradation of biomaterials in the human body

environment; tissue engineering: principles, methods and applications; standards and regulatory issues; new trends in R & D of biomaterials and tissue engineering.

EMEE6005. Renewable energy technology I: Fundamental (6 credits)

This course focuses mainly on different renewable energy technologies including hydro power, wind power, bioenergy, solar thermal, solar PV, energy storage, and energy usage. The specific course objectives are: (1) to have a deep understanding of the important role played by renewable energy in our energy supply; and (2) to grasp the fundamentals of different energy resources; (3) to understand energy storage and its important role in solving intermittency and other issues; and (4) to understand how to use energy more efficiently with solid state lighting and other energy saving technologies.

Topics include: renewable energy in a big picture; hydro power; wind power; solar thermal; solar PV; bioenergy; energy storage: intermittency and other issues; energy usage: solid state lighting.

Students who have taken and passed MECH6042 will not be allowed to take EMEE6005.

EMEE6006. Renewable energy technology II: Advanced (6 credits)

This course is on the working principles of advanced energy conversion devices including solar cells, fuel cells, batteries, photoelectrochemical (PEC) water splitting cells, and thermoelectric cells. Also covered are the energy carriers in different materials and the connection between different energy conversion devices. The specific course objectives are as: (1) to have a deep understanding of the energy carriers in different materials and their important roles in energy conversion; (2) to grasp the working principles of different energy conversion devices; (3) to be able to tell the differences and similarities between different energy conversion devices; and (4) to be able to design more efficient energy conversion devices.

Topics include: introduction: energy carriers in energy conversion cells; solar cells; fuel cells; electrochemical cells; photoelectrochemical (PEC) water splitting; thermoelectric cells.

Pre-requisite: EMEE6005 or for students who have previously passed MECH6042 or MECH6009 which have been obsolete with effect from 2014-2015 and 2011-2012 respectively

Students who have taken and passed MECH6043 will not be allowed to take EMEE6006.

EMEE6007. Energy and carbon audit (6 credits)

This course aims to: (1) provide students with the fundamental principles, skills and guidelines needed to carry out effective energy and carbon audits for the commercial and industrial sectors; (2) enable students to identify energy saving and carbon reduction measures and perform quantitative analysis to predict the energy savings and carbon reduction, environmental and economic benefits; and (3) enable students to verify the performance of implemented energy saving and carbon reduction measures.

Topics include: greenhouse gas emission; global warming; energy benchmarking; electrical distribution system; power quality and power factor; energy efficient lighting; motor; HVAC energy audit; refrigeration cycle; passive cooling; heating appliances; energy consumptions in compressors and pumps; energy saving measurements; local and international guidelines in energy and carbon audit; carbon footprint calculator.

Students who have taken and passed MECH6044 will not be allowed to take EMEE6007.

MECH6045. Nanotechnology: fundamentals and applications (6 credits)

Nanotechnology is a rapidly developing discipline which has emerged from foundations based in microtechnology built up during the past few decades. Many exciting engineering applications in nanotechnology have been proposed and some are already in use. The current intensive research activities world-wide make it highly likely that many more products and applications in nanotechnology will emerge in the next few decades. This course aims at: (1) to equip students with fundamental knowledge and concepts on micro- and nano-technology, and to enable the students to apply such knowledge in future careers in both industry and universities; (2) to enable students to understand the effects of material size on behaviour and properties, and from these to appreciate the new possibilities in both fundamental science and practical applications brought about by nanotechnology; and (3) to introduce students to promising and emerging applications of nanotechnology in energy storage/conversion, unconventional materials and optical metamaterials, and help students to further research and/or work in specific application areas.

Topics include: characteristic length scales, nanomaterials, nanostructures, physical properties of nanostructures, deposition techniques of nanofabrication, micro/nanolithography, high resolution analysis and characterization, scanning probe methods, nanoindentation, mechanical behaviours of bulk nanostructured materials, processing techniques for bulk nanostructured materials, ultrahigh strength of nanostructures, bio-nanotechnology, energy storage, energy conversion, nanophotonics, plasmonics, optical metamaterial.

Students who have taken and passed MECH6040 will not be allowed to take MECH6045.

MECH6046. Microsystems for energy, biomedical and consumer electronics applications (6 credits)

Microelectromechanical systems (MEMS) and microfluidics have gradually found numerous applications in modern energy, mechanical engineering and biomedical engineering applications. This course aims to provide students with the necessary fundamental knowledge and experience in the working principles, design, materials, fabrication and packaging, and applications of MEMS and microfluidic systems. MEMS and microfluidic devices are emerging platforms for modern engineering applications in biomedicine, chemistry, material sciences and micro-machines. This is the course that will introduce graduate students and practicing engineers into the growing field of microsystem engineering. Practical examples will be given when delivering each major topic. Teaching of the course is also strengthened with case studies on carefully chosen topics. At the end of this course, students who fulfill the requirements of this course will be able to: (1) demonstrate ability to understand the fundamental principles behind MEMS and microfluidic; (2) differentiate different MEMS and microfluidic techniques and understand their importance in modern engineering; (3) apply concepts of micro-systems for industrial applications, particularly in energy, mechanical engineering and biomedical engineering.

Topics include: MEMS and microsystem products; microsensors; microactuators; microfluidic devices; multidisciplinary nature of microsystem design and manufacture; fluid mechanics in microscaled flows; materials for MEMS and microfluidic devices; fluid mechanics in microscaled flows; fabrication techniques of MEMS and microfluidic devices; flow characterization techniques; flow control with microfluidics; microfluidics for life sciences and chemistry.

Students who have taken and passed MECH6032 will not be allowed to take MECH6046.

MECH6048. Dissertation (24 credits)#

It involves undertaking a dissertation or report on a topic consisting of design, experimental or analytical investigation by individual students. The objectives are to: (1) simulate a realistic working experience for students; (2) provide them an experience of applying engineering principles, engineering economics, business or management skills; and (3) train students to work independently to obtain an effective and acceptable solution to industry-related or research-type problems.

MECH7010. Contemporary robotics (6 credits)

This course aims to explore the major technologies related to modern robotic systems, including the components and working principles of robots, automatic and computer-aided control, kinematics and control of industrial robotic manipulators, humanoid and biomimetic robots. The specific course objectives are listed as follows: (1) to have a comprehensive understanding of robotic systems in terms of their principles, historical evolutions, and applications for both industrial and civilian applications; (2) to understand the mathematical foundations, designs, data processing, and real-time control of various sensing and actuation units which comprise a robotic system; (3) to study the robot kinematics modelling, and the basic knowledge of intelligent motion planning that can enable effective manipulation in various applications; and (4) to explore the challenges and trends in contemporary robotic research, and the future directions for application of robotic components.

Topics include: a) Historical and contemporary robotic systems; b) Concept and components of robots, sensors and actuators; c) Robot kinematics; d) Robotic control and human interaction; e) Intelligent motion planning and localization; f) Applications and challenges of robots; g) Social, economic and ethical aspects of robotic applications.

MECH7012. Principles of engineering management (6 credits)

The focus of this course is on the basic principles, methods, and functions of engineering management. An overview of systems engineering is provided, with coverage on the design and management of an enterprise as an integrated system. The course objectives are: (1) acquire the essential principles of engineering management and understand how to apply these principles in daily practice in industry; and (2) understand and apply methods for managing the operations of engineering companies in the global business environment.

Topics include: systems engineering; core concepts and tools for the management of operations: operations planning and control functions, ERP systems; contemporary topics and approaches in engineering management: supply chain, green management, ethics, corporate social responsibility and compliance, risk and crisis management.

CIVL6002. Advanced finite elements (6 credits)

Equilibrium and virtual work principle; variation principle; numerical integration; computer applications; convergence and error estimate; hybrid and mixed methods for multi-field problems; enhanced and assumed strain method; nonlinear problems.

Special approval has been given by the Senate for candidates admitted to the part-time mode of the curriculum in the academic year 2016-17 to take additional discipline courses of the same credit value in lieu of the capstone experience to satisfy the curriculum requirements.

Cross-listed Undergraduate courses

The following cross-listed undergraduate courses, which are not counted for the fulfilment of the curriculum requirements and the classification of award of the degree of MSc(Eng) in Mechanical Engineering, are provided to make up the academic discrepancy and strengthen mechanical engineering fundamentals for students from different academic background, e.g. overseas curricula or non-local universities. Students can take up to 12 credits of courses from the list below:

MECH4411. Heat transfer (6 credits)

This course is on the fundamental principles of heat transfer, covering heat conduction, heat convection and heat exchangers. The course objectives are: (1) to provide an understanding of fundamental principles of heat transfer; and (2) to enable students to use the fundamental principles for conducting thermal analysis and design of engineering problems. At the end of this course, students who fulfill the requirements of this course will be able to: (1) demonstrate an understanding of the principles that govern heat transfer processes; (2) analyze heat-transfer problems quantitatively; and (3) identify relevant engineering solutions in thermal systems.

Topics include: Fourier's law; heat-conduction equation; thermal conductivity; conduction; fins; basic convection principles; laminar and turbulent heat transfer in tubes and over plates; Reynolds analogy; types of heat exchangers; overall heat-transfer coefficient; log mean temperature difference; effectiveness-NTU method; heat exchanger design.

Assessment: 10% practical work, 10% continuous assessment, 80% examination

MECH4415. Applied stress and strength analysis (6 credits)

The aims of this course are to: (1) formulate three-dimensional theory of elasticity and introduce the theory of plasticity; (2) introduce analytical and numerical methods for solving practical engineering problems; and (3) introduce theories of fracture and fatigue and their applications to practical engineering problems.

Topics include: theory of elasticity; plastic analysis; finite element methods for two- and three-dimensional continua; rectangular plate bending; fracture mechanics.

Assessment: 15% practical work, 15% continuous assessment, 70% examination

MECH4421. Viscous flow (6 credits)

This course aims to: (1) elucidate the advanced dynamics of liquids and gases, including steady and unsteady solutions of the Navier-Stokes equations, (2) perform a study on the properties, mass flux and momentum flux of a boundary layer, (3) explain the basic mechanics of a compressible fluid flow and applications to aerodynamics, (4) discuss the ideas of surface tension and stability in simple multiphase flows; To derive the Plateau-Rayleigh instability as the basic governing model for the linear stability of droplet formation, and (5) understand the complex flow patterns behind bluff bodies, mechanisms associated with vortex shedding and drag force; To characterize the low Reynolds number flow around a sphere and to measure viscosity using the Stokes' drag formula, and (6) introduce elementary concepts of turbulence.

Topics include: continuity and Navier-Stokes equations; Laminar boundary layers; Surface tension; Elementary concepts of compressible flows and shock waves; stability theory; flow behind bluff bodies; low Reynolds number flows and turbulent flows.

Assessment: 10% practical work, 10% continuous assessment, 80% examination

Course approved for reimbursement from the Continuing Education Fund (CEF) (applicable to Hong Kong Residents only)

MECH6034. Computer-aided product development (CAPD) (6 credits)