

Course Code	Course Title	Unit	Sem	Course Description	Learning Outcomes	Pre-requisites	Co-requisites	Preclusions	Syllabus	Assessment	Illustrative Reading List
ME2114	Mechanics of Materials	4	2	ME2114 is an intermediate mechanics course on the failure and deformation of elastic structures. Common criteria for determining failure of brittle and ductile materials will be introduced and applied for the failure analyses of thin-walled pressure vessels and slender structures. Failure of slender structures due to buckling is included. The course will also present several energy-based methods for determining the deformation of slender structures and show how energy methods lead to the Finite Element Method – a common tool for computational stress analysis.	<ul style="list-style-type: none"> Understand and apply yield and fracture criteria. Carry out stress analysis of thin-walled / slender structures. Understand and apply energy-based methods to determine the deformation of complex structures Understand instability of columns and able to determine the critical load of slender structures under axial compression Understand the principle of minimum potential energy and its application through the finite element method. 	ME2112	Nil	ME1103/ME2114/ME2114E	<ul style="list-style-type: none"> Failure criteria Analysis of pressure vessels and slender structures under combined loading Principle of minimum potential energy Instability of structures Work-energy balance and Castigliano theorem Finite element method 	Quiz, Lab Tests Final Exam	NA
ME2135	Intermediate Fluid Mechanics	4	2	This course aims to introduce fundamentals of fluid dynamics covering notions of the continuum hypothesis, flow kinematics, mathematical tools for flow visualization, material derivative, fluid acceleration, conservation laws, Euler and Navier-Stokes Equations, inviscid flows, potential flows, viscous flows, creeping flows and boundary layer flows. Review of relevant mathematical tools to support the theory will accompany the topics when and where it is required.	<p>On successful completion of this course, the student will be able to:</p> <ol style="list-style-type: none"> Apply angular momentum principle and dimensional analysis to analyse the performance of pumps, perform pump-system matching and assess the likelihood of cavitation occurrence. Understand the concepts of vorticity, circulation, irrotationality, stream function and velocity potential function, and apply these concepts to solve simple potential flow problems involving the superposition of elementary flows. Identify and discuss the features of external flow past immersed bodies and calculate the lift and drag forces for typical body shapes. Describe and explain the phenomenon of boundary layer on a body (at this stage, a flat plate) and estimate the drag force exerted. Analyse and design an a erodynamic body with minimum drag force. 	ME2134/ME2134E/TME2134	Nil	TME2135/ME3123	<p>Fluid Machinery Pump classification for dynamic and positive-displacement pumps. Basic velocity triangles and rotordynamics of centrifugal and axial-flow pumps. Use of dimensional analysis to simplify pump characteristic curves. Specific speed and pump selection. Matching of pump and system requirements. Physical phenomenon of cavitation in pumps and quantification of cavitation risk and damage.</p> <p>Potential Flow Ideal and irrotational flow. Continuity equation. Rotation, vorticity and circulation. Stream function and velocity potential of basic flows, such as a uniform flow, source, sink, vortex and doublet. Linearity of potential flow. Flow past a circular cylinder and the lift on a rotating cylinder. D'Alembert's paradox, Kutta Joukowski Theorem and Magnus Effect. Method of images.</p> <p>Viscous Flow Differences between Ideal(Inviscid) and Real(Viscous) Flows. Description of fluid motion and the substantive derivative. Navier-Stokes equations and some exact solutions. Prandtl's Laminar Boundary Layer Theory. Solution of laminar boundary layer flow on a flat plate (Blasius solution), Notions of boundary layer, displacement and momentum thicknesses. Drag on flat plate (von Karman integral equation). Boundary layer separation and control. Comparison between laminar and turbulent boundary layers. Turbulent flow and time averaging, equations of motion for turbulent flow, structure of the turbulent boundary layer and the law of the wall; turbulence models, velocity profiles in turbulent boundary layer and parameters of turbulent boundary layer. Boundary layer with transition. Flow around bluff and streamlined bodies. Drag reduction techniques.</p>	100% CA – Online Assignment, Lab report, Quiz	<p>Supplementary reading:</p> <ol style="list-style-type: none"> "Introduction to Fluid Mechanics" by R. W. Fox, A. T. McDonald & P. J. Pritchard, John Wiley & Sons, 8th Edition, 2012. "Fluid Mechanics: Fundamentals and Applications", Y. A. Cengel and J. M. Cimbala, McGraw-Hill, 3rd Edition, 2014. "Mechanics of Fluids" by M. C. Potter, D. C. Wiggert & M. Hondzo, Prentice Hall, 4th Edition, 2012. "A Physical Introduction to Fluid Mechanics", A. J. Smits, John Wiley & Sons, 1st Edition, 2000. "Mechanics of Fluids" by I. H. Shames, McGraw-Hill, 4th Edition, 2003. "Engineering Fluid Mechanics" by C. T. Crowe, D. F. Elger, J. A. Roberson & B. C. Williams, John Wiley & Sons, 9th Edition, 2010. "Fluid Mechanics" by J. F. Douglas, J. M. Gasiorek, J. A. Swaffield & L. B. Jack, Prentice Hall, 5th Edition, 2005. "Fluid Mechanics with Engineering Applications" by J. B. Franzini & E. J. Finnemore, McGraw-Hill, 10th Edition, 2002. "Mechanics of Fluids" by B. S. Massey, Taylor & Francis, 9th Edition, 2012. "Applied Fluid Mechanics" by R. L. Mott, Prentice Hall, 6th Edition, 2006. "Elementary Fluid Mechanics" by R. L. Street, G. Z. Watters & J. K. Vennard, John Wiley & Sons, 7th Edition, 1996. "Fluid Mechanics" by V. L. Streeter, E. B. Wylie & K. W. Bedford, McGraw-Hill, 9th Edition, 1997. <p>Compulsory reading:</p> <ol style="list-style-type: none"> "Fluid Mechanics" by F. M. White, McGraw-Hill, 7th Edition, 2011. "Fundamentals of Fluid Mechanics" by B. R. Munson, D. F. Young, T. H. Okiishi & W. W. Huebsch,, John Wiley & Sons, Inc., 7th Edition, 2013.
ME2143	Sensors and Actuators	4	1	Primarily a foundational course for mechanical engineering students, this course introduces the basic principles and characteristics of various sensors for the measurement of mechanical quantities such as position, velocity, acceleration, force, and temperature. Topics that are also introduced are actuators for achieving motion, primarily various types of electric motors. This course also covers the generalised measurement and instrumentation system, the associated electronics, drivers and power supplies for the processing of the signals from the sensors and transducers and for driving the various actuators. Emphasis is placed on the knowledge required for the application of these sensors and actuators rather than on their design.	<p>On successful completion of this course, the student will be able to:</p> <ol style="list-style-type: none"> Apply Op Amp circuits for analog signal processing. Analyse circuit involving diodes, BJT transistors Design and implement digital circuits. Understand the basic principles and characteristics of DC and AC motors. Understand the basic principles and applications of various sensors. 	ME2104	Nil	ME2105	<p>1. Operational Amplifiers and Applications: Ideal Op-amp model. Inverting and non-inverting amplifier. Summer. Integrator. Voltage follower. Differential amplifier. Practical op-amp characteristics</p> <p>2. Semiconductor Electronics: Junction Diode. Zener diodes. Rectifiers. Voltage regulators. Transistors.</p> <p>3. Introduction to Digital Electronics: Boolean Algebra. Truth tables. Logic Gates. Combinational logic. Karnaugh Maps. Flip-flops and counters. Sequential logic.</p> <p>4. DC Motors: Magnetic field and circuits. DC motor principle. Types of DC motors. Torque-speed characteristics. Speed regulations.</p> <p>5. Review of AC Power: Single and three phase systems. Star and delta configurations. Line and phase quantities.</p> <p>6. AC Motors and Stepper Motors: Principle of operation. Torque-speed characteristics. Induction motors and stepper motors.</p> <p>7. Sensors and Transducers: Bridges and their applications. Variable resistance elements: potentiometers, strain gauges, thermistors, RTDs. Variable reluctance elements: differential transformers, variable reluctance transducers. Capacitive transducers. Thermal couples. Piezoelectric effect. Selection of sensors.</p>	Lab Final Examination	NA
ME3000	Independent Study I	2	1 & 2	This course encourages students to become independent and self-motivated learners, and promotes students' interest in research-based work. The course may consist of a series of laboratory-based projects or other academic prescriptions for the students' independent study amounting to approximately 65 hours of work over half or one semester. The academic scope is worked out between the student and supervisor. Topics taken under UROP and extension of FYP will not be considered for this course.	<p>On successful completion of this course, the student will be able to:</p> <ol style="list-style-type: none"> Design and conduct experiments, analyse, interpret data and synthesize valid conclusions; Design a system, component, or process, and synthesise solutions to achieve desired needs; and Identify, formulate, research through relevant literature review, and solve engineering problem reaching substantial conclusions. 	Nil	Nil	Nil	The scope is to be worked out between the student and his supervisor.	100% CA	NA
ME3001	Independent Study II	2	1 & 2	This course encourages students to become independent and self-motivated learners, and promotes students' interest in research-based work. The course may consist of a series of laboratory-based projects or other academic prescriptions for the students' independent study amounting to approximately 65 hours of work over half or one semester. The academic scope is worked out between the student and supervisor. Topics taken under UROP and extension of FYP will not be considered for this course.	<p>On successful completion of this course, the student will be able to:</p> <ol style="list-style-type: none"> Design and conduct experiments, analyse, interpret data and synthesize valid conclusions; Design a system, component, or process, and synthesise solutions to achieve desired needs; and Identify, formulate, research through relevant literature review, and solve engineering problem reaching substantial conclusions 	Nil	ME3000	Nil	The scope is to be worked out between the student and his supervisor.	100% CA	NA
ME3101	Mechanical Systems Design I	4	1 & 2	This is a group-based project that focuses on the design of a complete mechanical design product, often motivated by collaboration with industry partners, emphasising the design process, analysis, drawings, and prototyping. The major project may be preceded by smaller projects to instill familiarity and experience. Elements of commercialisation (e.g. market survey) and form-giving (aesthetics) may be incorporated. Students are required to submit a report, drawings, do a presentation, and take oral examinations.	<p>On successful completion of this course, the student will be able to:</p> <ol style="list-style-type: none"> Translate the needs of a customer into an effective design. Understand and critically weigh the pros and cons of a design. Be an effective member of a team on an engineering design project. Source parts, fabricate designs, and implement functional physical prototypes. 	ME2102	Nil	Nil	<p>This course revolves around groups of students designing and prototyping solutions for predetermined projects, often in collaboration with industry partners. Students will be assigned groups and projects based on availability. Each group will be assigned a faculty tutor who will mentor the group during regular meetings throughout the term, scheduled on a per-group basis.</p> <p>Groups will establish a set of criteria and objectives based on user/client interviews, ideate and design solutions to address the needs, build prototypes to realise their designs, and evaluate their prototypes against the objectives. Students will be assigned both individual and group deliverables relevant to their assigned project, often including work journals, design drawings, CAD files, physical demonstrations, oral presentations, and/or written reports. Evaluation of the project will be based on review of the deliverables by the assigned tutor and an outside examiner, incorporating input from the target client.</p>	100% CA	NA

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ME3102	Mechanical Systems Design II	4	1 & 2	This is a follow-up course from ME3101, a group-based project that focuses on the design of a complete mechanical design product, often motivated by collaboration with industry partners, emphasising the design process, analysis, drawings, and prototyping. Emphasis is placed on the integration of the components of the complete system and the optimisation of the final design. Effective group dynamics and the experience of the process and problems involved in translating paper design to prototype are key focuses of this course.	On successful completion of this course, the student will be able to: 1. Translate the needs of a customer into an effective design. 2. Understand and critically weigh the pros and cons of a design. 3. Be an effective member of a team on an engineering design project. 4. Source parts, fabricate designs, and implement functional physical prototypes.	ME3101	Nil	Nil	This course revolves around groups of students designing and prototyping solutions for predetermined projects, often in collaboration with industry partners. Students will be assigned groups and projects based on availability. Each group will be assigned a faculty tutor who will mentor the group during regular meetings throughout the term, scheduled on a per-group basis. Groups will establish a set of criteria and objectives based on user/client interviews, ideate and design solutions to address the needs, build prototypes to realise their designs, and evaluate their prototypes against the objectives. Students will be assigned both individual and group deliverables relevant to their assigned project, often including work journals, design drawings, CAD files, physical demonstrations, oral presentations, and/or written reports. Evaluation of the project will be based on review of the deliverables by the assigned tutor and an outside examiner, incorporating input from the target client.	100% CA	NA
ME3123	Applied Thermofluids (offered from AY26/27 for cohort AY24/25 & before)	4	2	This course covers advanced topics in thermodynamics and fluid mechanics. The thermodynamics component includes power and refrigeration cycles (Rankine, vapor compression), air standard cycles (Otto, Diesel, gas turbine), and principles of heat exchangers, with a focus on applications in practical energy systems. The fluid mechanics component of the course introduces students to the operating principles of hydraulic pumps and turbines, their applications, methods of selecting pumps to match system requirements, and how to avoid cavitation damage. Fundamentals of viscous fluid flow, the Navier-Stokes equations and some of their exact solutions will also be covered.	On successful completion of this course, the student will be able to: 1. Analyse, model and design power plants utilising water or air as working fluids. 2. Analyse, model and design vapour compression refrigeration systems. 3. Analyse heat exchanger performance and determine the overall heat transfer coefficient. 4. Apply angular momentum principle and dimensional analysis to analyse the performance of pumps, perform pump-system matching and assess the likelihood of cavitation occurrence. 5. Apply the Navier-Stokes equations to obtain exact and approximate solutions for elementary viscous flow problems.	ME2121 & ME2134	Nil	ME2135	Power and Refrigeration Cycles (6 hours): - Water as working fluid for power cycles - Rankine cycle, superheating and reheating - Vapour compression cycle Air Standard Cycles (6 hours): - Analysis of Otto, Diesel and Mixed cycles. - Gas turbine cycle Heat Exchangers (6 hours): - Introduction to parallel flow, counter flow and cross flow heat exchangers, UA-LMTD and ϵ -NTU methods, and unmixed /finned compact heat exchangers Turbomachines (9 hours): - Introduction, Classification and Terminology - Basic Energy Considerations - Angular Momentum Considerations - Pump Performance Characteristics - Pump Dimensionless Parameters and Similarity Rules - Matching of Pump and System Requirements - Cavitation Viscous Fluid Flow (9 hours): - Fluid Kinematics - Stress-Deformation Relations - Navier-Stokes Equations - Simple Solutions for Laminar, Viscous, Incompressible Flows - Introduction to Boundary Layers	Lab Tests Mid Term Assignments Final Examination	Compulsory reading: 1. Yunus A. Çengel; Michael A. Boles; Mehmet Kanoglu, "THERMODYNAMICS: AN ENGINEERING APPROACH, SI" 2. Frank M. White, "Fluid Mechanics" Supplementary reading: 1. Claus Borgnakke; Richard Edwin Sonntag, "Fundamentals of Thermodynamics" 2. Gordon Frederick Crichton Rogers; Yon Richard Mayhew, "Engineering Thermodynamics: Work and Heat Transfer" 3. Michael J. Moran; Howard N. Shapiro; Daisie D. Boettner; Margaret B. Bailey, "Fundamentals of Engineering Thermodynamics" 4. Philip M. Gerhart; Andrew L. Gerhart; John I. Hochstein, "Munson, Young and Okiishi's Fundamentals of Fluid Mechanics" 5. Robert W. Fox; Alan T. McDonald; Philip J. Pritchard, "Introduction to Fluid Mechanics" 6. Yunus A. Çengel; John M. Cimbala, "Fluid Mechanics"
EE3306/ME3163	Introduction to Cyber Physical Systems	4	1	The course introduces recent technological developments enabling cyber-physical systems, which in turn define Industry 4.0. Topics are organized under Internet of Things, Data Analytics, Robotics and Automation, and Additive Manufacturing. The course provides a common technology foundation for students in the Industry 4.0 Specialisation programme. This course is a core course in the Industry 4.0 Specialisation.		Nil	Nil	EE3306	The course will cover the following topics. Industry 4.0 (12 hrs): Cyber Physical Systems, Smart Manufacturing, Lights Out Industry, Digital Twin, Robotics and Automation: Robots for Smart automation, Collaborative Robotics, Sensors and Data. Internet of Things (6 hrs): Industrial Internet of Things, Data transmission, processing and storage, Cloud and Edge Analytics. Additive Manufacturing (6 hrs): 3D Printing technologies and process; Digital design, simulation and post-processing; Benefits of 3D printing in product design & development; Applications and case studies.		NA
ME3211	Mechanics of Solids	4	1	The course covers topics on: Linear elasticity in which the general equations of equilibrium and compatibility are derived, and its applications are illustrated for complex problems; Unsymmetrical bending of beams; Stresses in pressurised thick-walled cylinders in elastic and elasto-plastic regions; Stresses in rotating members; Introduction to mechanics of composite materials; and Experimental stress analysis with particular emphasis on optical methods. This is an elective course and is intended for students in Stage 3 and 4 who have an interest in the stress analysis of isotropic and composite materials. The materials in this course are applicable to chemical, civil, mechanical and aeronautical engineering.	On successful completion of this part of the course, the student will be able to: 1. Understand the fundamentals and applications of linear elasticity: Equilibrium, Compatibility, Constitutive relations, Airy stress functions, boundary conditions, and Thermal Stresses. 2. Determine the deformations and stresses in thick-walled cylindrical pressure vessels and rotating discs and shafts, and hence prescribe their performance limits. 3. Describe and apply the classical lamination theory of fiber-reinforced composite laminates.	ME2112 or ME2116	Nil	Nil	Basic equations of force equilibrium, compatibility and constitutive relations. Airy stress functions. Boundary conditions. Solutions of elasticity equations. Theory of thermal stresses. Thick-walled cylinders subjected to pressure loading, and their elastic-plastic behaviour. Compound cylinders. Rotating discs and shafts, interference fits, critical speeds. Introduction to composite materials. Classical lamination theory. Residual and fabrication stresses. Failure of composites.	Essay Final Examination	Supplementary reading: 1. A.C. Ugural and S.K. Fenster, "Advanced Mechanics of Materials and Applied Elasticity", Arnold (1987). 2. Arthur P. Boresi; Richard J. Schmidt, "Advanced Mechanics of Materials", J. Wiley (2020). 3. R.M. Jones, "Mechanics of Composite Materials", CRC Press, (2018) 4. R.R. Craig Jr., "Mechanics of Materials", John Wiley and Sons (2020)
EE3305/ME3243	Robotics System Design (Robotics)	4	1	This course will introduce the mobile robot systems' architecture and key components such as various sensor and actuator technologies. Various locomotion mechanisms adopted by robotic systems will be discussed. The course will also introduce basic principles of robot motion control. Robot Operating System (ROS) will be utilized for simulation in virtual environments.	At the end of the course the student will be able to 1. Analyse motion of different locomotion mechanisms. 2. Understand key working principles of selected sensors and actuators used in robots; and select appropriate sensors and actuators for a robot system to achieve a given task. 3. Apply basic robot motion control principles. 4. Utilize ROS for mobile robot simulation in a virtual environment.	Nil	Nil	EE3305	The course will cover the following topics. Introduction to Robotics: Definitions and history of robotics, robot components, robot Applications. Robot Sensors and Actuators: Various sensor principles and actuation technologies, degrees of freedom. Robot Locomotion: Introduction to legged and wheeled mobile robots. Wheeled Mobile robot kinematics. Robot Motion Control: Types of controls (proportional, integral and derivative), localization, path planning and navigation. Robot Operating System: Simulation of mobile robot(s) in a virtual environment. • Classification of engineering materials and their applications.	Group Projects/ Quizzes/ Assignments	Compulsory reading: NIL Supplementary reading: 1. Matorić, Maja J. The Robotics Primer. Mit Press, 2007. 2. Siegart, Roland, Ilah R. Nourbakhsh, and Davide Scaramuzza. "Introduction to Autonomous mobile robots." 3. Joseph, L. (2018). "Robot Operating System (ROS) for Absolute Beginners
ME3252	Materials Mechanical Engineering	4	1	This course covers the fundamentals of materials science, focusing on material selection for various engineering applications. Students will learn to identify different materials and compositions from both technical and economic perspectives. The course explores the mechanics of material failure, helping students understand how materials behave under mechanical loading. Additionally, students will apply knowledge of phase equilibria and transformations to predict microstructures and properties, equipping them with the tools to optimise material performance for specific engineering needs. The course bridges theoretical concepts with practical applications in material design and failure analysis.	- Identify different materials and compositions for various applications from both the engineering and economic point of view - Explain the mechanics of failure in materials - Apply the knowledge of phase equilibria and transformations to predict microstructures and properties	ME1102 or ME1103	Nil	Nil	• Materials failure such as fracture, fatigue, creep, wear, corrosion • Phase equilibria • Kinetics of phase transformations	Essays, Project, Mid Term Tests	NA

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ME3261	Computer-Aided Design and Manufacturing	4	1	<p>This course covers the principles of computer-aided tools: CAD and CAM, which are widely used in modern design and manufacturing industry.</p> <p>By introducing the mathematical background and fundamental part programming of CAD/CAM, this course provides the basics for students to understand the techniques and their industrial applications.</p> <p>The topics are: CAD: geometric modelling methods for curves, surfaces, and solids; CAM: part fabrication by CNC machining based on given geometric model; Basics of CNC machining; Tool path generation in CAD/CAM (Option to introduce a CAM software to generate a CNC programme for the machining of a part); Verification of fabricated part by CNC measurement based on given geometric model.</p> <p>The course is targeted at students specialising in manufacturing engineering.</p>	<ol style="list-style-type: none"> Understanding the basics of the mathematical models that form the tools for curve and surface construction in CAD packages. Apply mathematics through matrix and vector algebra to model free-form curves and surfaces from discrete data points. Understanding basic principles and programming techniques of computer-aided manufacturing (CAM) in relation to computer-aided fabrication of parts by machining and computer-aided verification of dimensions/tolerance by measurement. Integrate CAD modeling and different techniques of computer-aided machining and measurement through applications in a CAM environment. Complete an independent study project related to CAD/CAM. 	Nil	ME2162	Nil	<p>CAD: Geometric Modeling</p> <ul style="list-style-type: none"> Curve segment models Composite curve construction Surface patch models Composite surface construction Solid model data structure and techniques <p>CAM: Fabrication of Part by CNC Machining based on Geometric Model</p> <ul style="list-style-type: none"> Basics of CNC Turning and Milling Tool path generation in CAD/CAM <p>CAM: Verification of Fabricated Part by CNC Measurement based on Geometric Model</p> <ul style="list-style-type: none"> Geometric Dimensioning and Tolerancing Basics of Computer-automated Measurement. 	Essays Final Examination	NA
ME3263	Design for Manufacturing and Assembly	4	1	<p>This course teaches product design for manufacture and assembly. It covers the details of design for manufacture and assembly (DFMA) methods for practicing engineers and also allows for learning of sustainable product design and manufacturing. The topics covered include DFMA Introduction, Selection of materials and manufacturing processes; Product design for manual assembly; Design for automatic assembly and robotic assembly; Design for manufacturing, including machining and injection molding; Design for Additive Manufacturing. The course is targeted at students majoring in manufacturing.</p>	<ol style="list-style-type: none"> Understand and apply the principles of design for material forming processes Understand and apply the principles of basic machining practice and principles of design for machining Apply the knowledge in selecting material forming and additive manufacturing processes for specific jobs. Understand the principles of assembly planning, and the ability to identify the assembly design bottlenecks. Apply design for assembly techniques to determine the average assembly time and cost Understand the principles of additive manufacturing and able to apply additive manufacturing in design Understand how additive manufacturing has evolved into a direct manufacturing process and system selection can influence final part quality 	Nil	ME2162/ ME3162	Nil	<ul style="list-style-type: none"> DFMA Introduction Selection of materials and manufacturing processes Product design for manual assembly Design for automatic assembly and robotic assembly Design for manufacturing, including machining and injection molding Design for Additive Manufacturing 	Project Final Examination	NA
ME3281	Microsystems Design and Applications	4	2	<p>The course generates an appreciation of the interdisciplinary nature of microsystems and their impact on various application domains, including but are not limited to, consumer electronics, healthcare, and manufacturing. Secondly, it enables students to learn and apply science and technology of miniaturisation.</p> <p>The major topics include: An overview of the principles, Semiconductor materials and processes, System-level design and applications of microsystems; Properties of semiconductor; Fundamentals of dynamics and vibration; Micro flexural suspension designs; Piezoresistivity and applications in sensors; Electrostatics and Capacitance; Electrostatic micro actuators; Micro optics and miniaturised imaging systems; Thermal actuators and sensors; Biosensors; Fabrication in MEMS. The target students are those having a keen interest in both mechanical and electrical engineering subjects as well as material processing topics.</p>	<p>On successful completion of this course, the student will be able to:</p> <ol style="list-style-type: none"> Understand the advantages of microsystems and their application areas. Design basic microelectromechanical systems (MEMS) based actuators for translational and rotational motions. Design basic optical MEMS devices including micro-mirrors and micro-mirror arrays for optical microsystems. Design basics of microsystems-based sensors, including micro-accelerometers, micro-gyroscopes, and pressure sensors. Understand the basics of microfluidic devices, including micro-pumps, micro-channels, micro-valves, and micro-flow sensors. Understand the basics of microfabrication processes. 	Nil	Nil	Nil	<ol style="list-style-type: none"> Introduction and Overview of Microsystems Technology Microfabrication Fundamentals Materials for Microsystems Beams and Diaphragms for Microsystems and Micro Suspension Designs Microactuators Microsensors Optical Microsystems Microfluidics and Bio-MEMS 	Project Quizzes/Tests	NA
ME3291	Numerical Methods in Engineering	4	2	<p>This elective course introduces students to fundamental concepts of numerical analysis as a powerful tool for solving a wide variety of engineering problems. The topics covered include numerical solution of linear systems of algebraic equations, numerical solution of nonlinear algebraic equations and systems of equations, elementary unconstrained optimisation techniques, regression and interpolation techniques, numerical differentiation and integration, as well as the numerical solution of Ordinary Differential Equations (ODE).</p> <p>Applications are drawn from a broad spectrum of diverse disciplines in Mechanical Engineering. The course will also introduce the use of scientific computing software packages for the numerical solution of practical engineering problems.</p>	<ol style="list-style-type: none"> Perform numerical integration using techniques such as the Trapezoidal Rule, Simpson's Rule, and Gauss Quadrature. Numerically solve Ordinary Differential Equations (ODE) using techniques such as the Runge-Kutta Method (RK23, RK45). Numerically solve linear systems of algebraic equations using techniques such as Gaussian Elimination and LU Decomposition Apply elementary unconstrained optimisation techniques such as the method of line searches, Newton's Method, and Gradient Methods Perform regression and interpolation of numerical data using techniques such as Linear and Polynomial Regression, Lagrange Interpolating Polynomials, Inverse Interpolation, and Spline Interpolation Numerically solve nonlinear algebraic equations using iterative techniques such as the Bisection Method, the Method of False-Position, Simple Fixed-Point Iteration Method, the Newton-Raphson Method, and the Secant Method. 	MA1505 & MA1512 & MA1513	Nil	Nil	<ul style="list-style-type: none"> Introduction Round-off Error and Computer Arithmetic Machine Accuracy LU Decomposition and Matrix Inversion Gaussian Elimination and LU Decomposition Pivoting and Matrix Inverse Roots of Equations (Bracketing Methods) Bisection Method Methods of False-Position Simple Fixed-Point Iteration The Newton-Raphson Method The Secant Method Systems of Nonlinear Equations Unconstrained Optimisation Methods of Line Searches Newton's Method Gradient Methods Least-Squares Regression and Interpolation Linear Polynomial Regression Lagrange Interpolating Polynomials Inverse Interpolation Spline Interpolation Numerical Differentiation and Integration The Trapezoidal Rule Simpson's Rules Gauss Quadrature Runge-Kutta Methods (RK23, RK45) 	Project Mark Tutorial Final Examination	NA
ME4105	Specialisation Study Course (Offshore Oil & Gas Technology)	4	1	<p>This module is designed to link staff research to teaching in the selected areas of specialisation offered by the Department. The module comprises a structured programme of seminars, term papers, and mini-projects to be given by a group of faculty members based on their current research interests in the specialisation area. The programme content differs for different specialisation areas. The module is intended for students pursuing a specialisation.</p>		Nil	Nil	Nil		100% CA	NA

Course Code	Course Title	Unit	Sem	Course Description	Learning Outcomes	Pre-requisites	Co-requisites	Preclusions	Syllabus	Assessment	Illustrative Reading List
ME4212	Aircraft Structures	4	2	This course covers torsion of open and closed non-circular thin-walled sections; bending of unsymmetric thin-walled beams; idealised beams; multi-cell torque boxes and beams; tapered beams; introduction to mechanics of fiber-reinforced composites; classical lamination theory; failure theories for composites. This is an elective course and is intended for students who are interested in the design and analysis of thin-walled structures, especially aircraft structures.	On successful completion of this part of the course, the student will be able to: 1. Apply the formulae for bending of thin-walled beams of unsymmetric sections, and determine the bending stresses and resultant shear flow. 2. Describe and explain the difference in shear stress distribution for torsion of open and closed thin-walled members. 3. Apply the approximation of idealized beams with stringers and sheets to beams of various cross-sectional and multi-cell configurations. 4. Understand basic elastic constants in fiber-reinforced composite materials at lamina level. 5. Apply classical lamination theory to determine effective laminate stiffness and load-deformation relations. 6. Apply failure criteria in analysis of laminated composite plates and structures.	Nil	Nil	Nil	Torsion and Bending of Thin-Walled Beams, Idealised Beams and Membrane • Basic equations • Torsion of non-circular sections • Warping functions • Stress functions • Membrane analogy • Shear stress distribution in a thin-walled member under torsion • Shear stress in open sections • Shear stress and shear flow in closed sections • Bending of unsymmetric sections • Bending stresses • Shear flow due to bending • Shear center • Idealised beams with stringers and sheets • Equations of bending and torsion for idealised beams Mechanics of Fiber-Reinforced Composite Materials and Structures • Elastic constants and constitutive relations for anisotropic and orthotropic materials • On-axis and off-axis stiffness and compliance of a fiber-reinforced composite lamina • The composite laminate • Classical Lamination Theory • The laminate stress-strain relations • Special laminates • Fabrication stresses • Hygrothermal behaviour of composites • Failure of composite structures	Assignments/ Final Examination	Compulsory reading: 1. Ronald F. Gibson, "Principles of Composite Material Mechanics" 2. T.H.G. Megson, "Aircraft Structures for Engineering Students", Butterworth-Heinemann, 5th Ed. (2013). Supplementary reading: 3. David W A Rees, "Mechanics Of Solids And Structures (2nd Edition)" 4. T.H.G. Megson, "An Introduction to Aircraft Structural Analysis", Butterworth-Heinemann, (2010). 5. C.T. Sun, "Mechanics of Aircraft Structures", John Wiley & Sons, 2nd Ed. (2006). 6. J. Cutler, "Understanding Aircraft Structures", Blackwell, 4th Ed. (2005) 7. M. W. Hyer; Scott R. White, "Stress Analysis of Fiber-reinforced Composite Materials". 8. Bhagwan D. Agarwal; Lawrence J. Broutman; K. Chandrashekhara, "Analysis and Performance of Fiber Composites" 9. Carl T. Herakovich, "Mechanics of Fibrous Composites".
ME4223	Thermal Environmental Engineering	4	1	This course aims to integrate knowledge in thermodynamics, heat transfer and fluid mechanics to design and simulate air-conditioning systems, as well as to estimate and analyse the energy performance of buildings and other spaces. Major topics discussed include applications of refrigeration and air-conditioning, thermal basics, psychrometrics, comfort and health, heat gains through building envelopes, cooling load calculations, air-conditioning design calculations, air-conditioning systems, air-conditioning plants and equipment, energy estimation and energy performance analysis. The course is designed for third and final-year students who are interested in the air-conditioning and improvement of energy efficiency of buildings and other spaces.	On successful completion of this course, the student will be able to: 1. Apply heat transfer principles in estimating the thermal loads of building and other spaces. 2. Apply principles of thermodynamics, heat transfer and fluid mechanics in designing and simulating air-conditioning systems. 3. Estimate the energy requirements of buildings and other spaces. 4. Analyze the energy performance of buildings and other spaces. 5. Improve the energy performance of buildings and other spaces. 6. Evaluate feasibility of alternative energy sources for buildings and other spaces	ME2121	Nil	TME4223	Applications and Basics: Applications of Air Conditioning and Refrigeration. Review of Thermal Principles. Psychrometrics, Comfort and Health: Properties of moist air. Humidity measurement. Psychrometric chart. Psychrometric processes. Comfort. Indoor Air Quality. Heat gains through building envelopes: Solar heat gain, fenestration and shading coefficient, Thermal performance of building envelopes, Overall Thermal Transmittance Value, Green-mark incentive scheme calculations: Manual and computerized methods of load estimation. Air-conditioning Cooling Load CG Design Calculations: • Sensible and Latent Loads • Room Load Ratio Line • Supply Air Quantity • Cooling Capacity Air-conditioning Systems: • All-air • All-water • Air-water • Heat Pump and Solar-assisted Systems Air-conditioning Plants, Equipment and Systems: • Vapour-Compression Refrigeration • Chillers • Cooling and Dehumidifying Coils • Cooling Towers • District Cooling Energy Estimation and Energy Performance Analysis: • Computer-aided Energy Estimation • Energy Performance Measurement and Analysis	Quizzes Mid Term Final Examination	Compulsory reading: Stoecker, W.F. and Jones, J.W., "Refrigeration and Air Conditioning", McGraw-Hill Book Company, 2nd Edition, 1982. Supplementary reading: ASHRAE Handbook of Fundamentals. Kreider, J.F., Curtiss, P.S. and Rabl, A., "Heating and Cooling of Buildings", McGraw-Hill Inc., 2002.
ME4226	Energy and Thermal Systems	4	1	This course covers a number of topics beginning with a treatment of the properties, heat and work transfers of real gases vapours. The course focuses on the sub-systems related to energy efficient systems such as cogeneration. The major topics are the design procedure of heat exchangers, performance of absorption refrigeration systems. Two main topics under cogeneration are introduced. These are microturbine cogeneration and biomass cogeneration. The students are provided with the status of these technologies, and provided with the technical, financial and environmental performance. Case studies of cogeneration plants found locally and regionally provide students with actual operating experience.	On successful completion of this course, the student will be able to: 1. Describe real gas behavior using equations of state and compressibility charts, derive thermodynamic equations. 2. Compute work and heat exchanges for real gas processes using generalized charts. 3. Design crossflow shell and tube heat exchangers and flat finned heat exchangers, considering material selection and core geometries. 4. Explain single-stage and two-stage absorption systems, and address operational problems. 5. Detail the operation, advantages, and financial analysis of microturbines cogeneration systems. 6. Describe biomass cogeneration systems, their benefits, performance monitoring, and calculate efficiency and carbon dioxide mitigation.	ME2121	Nil	Nil	Real Gas Properties and Processes Compressibility factor z and behaviour of real gases as depicted on specific compressibility chart; Van Der Waals, Beatty-Bridgeman, Redlich-Kwong, Virial equations of state; generalized compressibility chart, z-critical, Obert-Nelson reduced isometrics; determination of p,v,T values. Exact differential, +1, -1 rules, differentials of u, h, g and a, Tds equations; Maxwell relations; determination of non-measurable properties using measurable properties, cp, cv, β, κ and μ. du, dh, ds expressed in terms of measurable properties and their partial derivatives. Computational procedures. The fugacity factor. Derivation and construction of enthalpy, entropy and fugacity charts, use of these charts for thermodynamic processes. Absorption Refrigeration Vapour compression and absorption cycles, p-c-T and h chart for Li-Br water system. Representation as source-sink system, ideal COP. Simple cycle, inclusion of heat exchanger, performance calculation. Crystallization and capacity control. Two-stage Li-Br system and ammonia water systems. Design of Heat Exchanger Types of heat exchanger core geometries. Nomenclature and geometric properties of circular and finned flat tube heat exchangers, free flow area, frontal area, hydraulic radius, surface and volumes ratios and relationships. Efficiency of fins and finned tubes, overall heat transfer coefficients, pressure drop. Step-by-step design and verification procedures for circular and finned flat tube heat exchangers. Pressure loss computations. Comparison of different design outcomes. Microturbine Technology and Application Types of microturbines in the market and their applications, advantages and disadvantages compared with other technologies such as fuel cells and Stirling engines. Basic principles of operation of microturbines. Installation and performance testing of a microturbine system for power and cooling applications. Environmental effects on power output and efficiency. Industrial and commercial applications. Thermo-economic performance of microturbine applications. Biomass cogeneration Global and regional biomass resources and supply. Economic and environmental benefits of biomass utilization. Biomass cogeneration, regional and local installations, Biomass cogeneration systems and subcomponents design, operation and selection. Large-medium and small scale systems, plant flow processes, emission control, condensing systems. Waste heat applications. Performance monitoring procedure. Properties and characteristics of biomass fuels, moisture content, gravimetric analysis, HHV and LHV. Exhaust gas flow rates and properties. Technical performance, boiler and cogeneration efficiencies. Financial (IRR and payback period) and simple environmental impact analyses of biomass cogeneration system.	Assignments Mid Term Final Examination	Compulsory reading: Gordon J. Van Wylen and Richard E. Sonntag, "Fundamentals of Classical Thermodynamics", John Wiley and Sons, Second Edition (SI) Wilbert F. Stoecker and Jerold W. Jones, "Refrigeration and Air Conditioning", McGraw-Hill, Second Edition W. M. Kays and A.L. London, "Compact Heat Exchangers", Kreiger, Third Edition.
ME4227	Internal Combustion Engines	4	2	This course provides a detailed introduction to the working principles of all kinds of internal combustion (IC) engines, the major components and the functions of spark-ignition and compression-ignition engines, the parameters and characteristics used to describe IC engine operation, the necessary thermodynamics and combustion theory required for a quantitative analysis of engine behavior, the measurement of IC engine performance, the design of combustion chamber and its effect on the performance of IC engines, the formation of emissions and their control, supercharging, heat transfer and heat losses, friction and lubrication etc.	1. The students will acquire a sound knowledge of the working principles of all kinds of internal combustion engines 2. Know the structure of IC engines 3. Understand the design of IC engines 4. Test the performance of IC engines and understand the methods to detect and solve the potential problems faced in practice 5. Test and analyze the emissions of IC engine and the methods of improvement 6. Understand the analytical methods to estimate the performance of IC engines, and appreciate the methods to optimize it.	Nil	Nil	Nil	1. The structure, major components and working principle of internal combustion (IC) engine. 2. Internal combustion engine performance parameters and characteristics 3. Ideal Air-standard cycles and their analysis 4. Fuel-air cycles and actual cycles 5. Fuel supply system and their effect on the performance of IC engines 6. Ignition system and ignition timing 7. Combustion process and combustion chambers design 8. Energy losses and cooling system 9. Engine emissions and their control 10. Two stroke engines 11. Biofuels and applications in IC engine	Project Mid Term Test Final Examination	Compulsory reading: Internal Combustion Engine, by V Ganesan, published by the McGraw-Hill companies, ISBN 10-0-07-064817-4. Supplementary reading: Internal Combustion Engine Fundamentals, by John B. Heywood, Published by McGraw-Hill book company, ISBN 0-07-028637-X.

Course Code	Course Title	Unit	Sem	Course Description	Learning Outcomes	Pre-requisites	Co-requisites	Preclusions	Syllabus	Assessment	Illustrative Reading List
ME4231	Aerodynamics	4	2	<p>This course introduces to students the basic concepts/ theories/ applications in aerodynamics.</p> <p>Major topics are: Characteristics and parameters for airfoil and wing aerodynamics; Incompressible flow past thin airfoils and finite-span wings; Aerodynamic design considerations; Compressible subsonic, transonic and supersonic flows past airfoils and supersonic flow past thin wings.</p> <p>The course is targeted at students who are interested in aerodynamics, especially those who intend to work in the aviation industry or those who intend to conduct R & D work in the aerodynamics area.</p>	<p>On successful completion of this course, the student will be able to:</p> <ol style="list-style-type: none"> 1. Apply the fundamental principles governing aerodynamics in different flow regimes 2. Apply the theory of supersonic flow around thin airfoils to obtain the corresponding values of lift, drag and moment. 3. Understand various aerodynamics principles which include relation between lift acting on and circulation around an airfoil, starting vortex, Kutta condition etc. 4. Understand the function, principle and design of various components of an aircraft which include control surfaces and drag reduction/lift enhancement devices etc. 5. Apply the Thin Airfoil Theory to calculate the aerodynamic parameters of an airfoil. Apply the Prandtl Lifting Theory to calculate the aerodynamic parameters of a wing. 6. Understand various CFD schemes such as the Panel Method and Vortex Lattice Method and the corrections for applying the incompressible results to subsonic flow conditions. 	ME2134	Nil	Nil	<p>Characteristics Parametric for Airfoil and Wind Aerodynamics:</p> <ul style="list-style-type: none"> • Basic components of an aeroplane • Airfoil nomenclature and geometric parameters • Wing geometric parameters • Characterisation of aerodynamic forces • Aerodynamic force and moment coefficients <p>Two-dimensional Incompressible Flows Around Thin Airfoils:</p> <ul style="list-style-type: none"> • Circulation and generation of lift • Kutta-Joukowski Theorem • Thin airfoil theory and its application to symmetric, cambered and flapped airfoil • Panel method <p>Incompressible Flow Around Finite-span Wings:</p> <ul style="list-style-type: none"> • Biot- Savart Law and Helmholtz's Vortex Theorems • Prandtl's Lifting Line Theory • General and elliptical lift distribution • Vortex Lattice Method <p>Aerodynamic Design Considerations:</p> <ul style="list-style-type: none"> • The ideal airfoil • High lift devices, including single and multi-flap systems, power augmented lift, rippled trailing edge and vortex lift • Drag reduction devices, including laminar flow control, riblets and winglets <p>Compressible Subsonic and Transonic Flows Around Airfoils:</p> <ul style="list-style-type: none"> • Compressible subsonic flows • Linearised thin airfoil theory for compressible flow • Transonic flow past unswept airfoils • Design considerations to overcome transonic flow problems • Swept wings at transonic speeds • Transonic aircraft <p>Two-dimensional, Supersonic Flows Around Thin Airfoils:</p> <ul style="list-style-type: none"> • Linear theory • Busemann's theory 	<p>Quiz/Test</p> <p>Final Examination</p>	
ME4233	Computational Methods in Fluid Mechanics	4	1	<p>Computer simulation and modelling has become an important tool in advanced mechanical engineering, e.g. computational fluid dynamics (CFD) software which is used for fluid-related problems. This course introduces students to the principles and methodologies under the hood of typical CFD software. Major topics include numerical discretisation, stability and accuracy analysis, and methods for solving incompressible viscous fluid flow and convective heat transfer problems. Students will also experience writing a code/script to solve simple fluid problems. At the end of this course, students will have a working knowledge of the basic principles of fluid flow simulation and implementation of computational methods in solving complex problems.</p>	<p>On successful completion of this part of the course, the student will be able to:</p> <ol style="list-style-type: none"> 1. Understand the fundamental issues of finite difference discretization. 2. Generate finite difference schemes and apply them to reduce a partial differential equation to a coupled set of ordinary differential equations or algebraic equations. 3. Do stability and accuracy analysis by the matrix method. 4. Do stability analysis by Von Neumann method. 5. Solve Poisson and elliptic-type equations arising from incompressible fluid flows. 6. Formulate and discretize equations of incompressible viscous fluid flow (differential and finite-volume form). 7. Solve incompressible fluid flow through implementing a typical methodology in a 2D problem. 	ME2134 Or ESP2106	Nil	Nil	<ul style="list-style-type: none"> • Basic theory of numerical discretisation • Finite difference discretisation • Stability and accuracy analysis • Solution methods for Poisson and elliptic type equations • Conservation laws and finite volume discretization • Formulation and solution methods for viscous incompressible fluid flows 	<p>Essays</p> <p>Final Examination</p>	
ME4241	Aircraft Performance, Stability and Control	4	1	<p>The course is concerned with the flying qualities of flight vehicle and the impact of aerodynamics, propulsion, structures and control systems on flight performance. The course is designed for aeronautical specialisation students who intend to work in the aerospace and defence industries.</p> <p>As such there is a strong emphasis on practical methods to estimate flight performance metrics required by industrial specifications e.g. Federal Air Regulations Part 23 and 25 and MIL-SPEC-8785. Industrial software e.g., MatLab (or open-source equivalent Octave, SciLab) will be used to compute flight performance metrics.</p>	<ol style="list-style-type: none"> 1. Appreciate the interplay of aerodynamics, propulsion, structures and control on flight performance, stability and control. 2. Know the standard atmospheric models and the effect of atmospheric conditions on flight performance, stability and control. 3. Estimate aircraft performance metrics for a given aerodynamic configuration. 4. Assess flight stability and flying qualities via the use of stability derivatives. 5. Apply and interpret industrial specifications e.g. Federal Air Regulations and MIL specifications for conventional commercial and military aircrafts 6. Understand the performance, stability and control characteristics for experimental and research flight vehicles. 	Nil	Nil	Nil	<p>Part 1: Aircraft Performance</p> <ul style="list-style-type: none"> • Straight and Level Flight • Climbing and Gliding • Power Requirement Curve • Take off and Landing Field Length • Range estimates, Breguet's equation • Endurance estimates, Turning Performance • Generation of flight envelopes <p>Part 2: Aircraft Stability and Control</p> <ul style="list-style-type: none"> • Static longitudinal stability • Static margin • Static directional stability • Longitudinal dynamic stability • Phugoid and short period modes • Lateral dynamic stability, roll, spiral and Dutch roll modes • Flying qualities assessment <p>Matlab or equivalent software (Octave, SciLab) will be used to compute performance and stability metrics with reference to industry FAR and MIL-SPEC requirements.</p>	<p>Tests/Assignments</p> <p>Final Examination</p>	
ME4242	Soft Robotics	4	1	<p>Soft Robotics introduces the usage of soft materials to construct and design integral parts of a robot like soft actuators and soft sensors.</p> <p>This course will introduce different types and genre of soft robots, mechanics of soft robots and the design, kinematics of control and applications of soft robots.</p> <p>The objective of this course is to introduce students to a new field of robotics that are made up of, in-part or as a whole, with soft materials and systems.</p>	<ol style="list-style-type: none"> 1. Define soft robots and the different classifications of soft robots 2. Describe the different kinds of soft materials used for robotic mechanisms and components. 3. Model the physical (e.g. electrical and mechanical) behaviour of such materials in response to different energy sources. 4. Explain how soft materials can be used as sensors 5. Explain how soft materials can be used as actuators 6. Design and realize active robotic components (e.g. sensors and actuators) based on soft materials. 7. Develop a mathematical model that describes the kinematic response of robotics mechanisms with soft materials 8. Build a soft robot system that is capable of fast locomotion and overcoming obstacle 	Nil	Nil	Nil	<ol style="list-style-type: none"> 1. Introduction to Soft Robotics and recent developments. Define soft robotics and the different types of soft robots developed in the recent years. 2. Biomimetics Introduce bio-inspired concept and designs of soft robots, including muscular hydrostat, growing/evolving structures etc 3. Soft Fluidic Robot Systems Introduce the concept of fluid-based inflation and associated material designs and electronics setup for fluidic control. 4. Electrical Driven Dielectric Elastomer. 5. Polymers Describe new types of magnetic/thermo/electrosensitive actuation materials, such as soft resins, shape memory alloys; polymers and resins 6. Mathematical Modeling Describe basic models for relating the pressure kinematics relationship of soft actuators. 7. Manufacturing methods Describe silicone mold-casting, direct 3D-printing, fabric welding methods, including their advantages and disadvantages. 8. Control of soft robots Explain fluidic PID control in detail 9. Example applications Introduce soft wearable robots, manipulation robots and locomotion robots 	<p>Group Project/ Individual Assignment</p>	<p>Supplementary reading:</p> <p>Liyu Wang, Surya G. Nuzuzaman, and Fumiya Iida. 2017. Soft-Material Robotics. Now Publishers Inc., Hanover, MA, USA.</p> <p>Alexander Verl, Alin Albu-Schäffer, Oliver Brock, Annika Raatz, 2016, Soft Robotics: Transferring Theory to Applications, Springer, Berlin, Germany.</p>

Course Code	Course Title	Unit	Sem	Course Description	Learning Outcomes	Pre-requisites	Co-requisites	Preclusions	Syllabus	Assessment	Illustrative Reading List
ME4245	Robot Mechanics and Control	4	1	<p>The course facilitates the learning of the fundamentals of robotic manipulators for students to appreciate and understand their design and applications. Successful completion allows students to formulate the kinematics and dynamics of robotic manipulators consisting of a serial chain of rigid bodies and implement control algorithms with sensory feedback.</p> <p>The course is targeted at upper-level undergraduates who have completed fundamental mathematics, mechanics, and control courses.</p> <p>Students will also gain a basic appreciation of the complexity in the control architecture and manipulator structure typical to new-generation robots.</p>	<ol style="list-style-type: none"> 1. Mathematically describe the position and orientation of a rigid object. 2. Given the mathematical model of the kinematics and dynamics of a robot, be able to physically visualize the robot's motion capabilities 3. Develop the kinematic models of the robotic manipulators 4. Derive the dynamic models of the robotic manipulators using Lagrangian and/or Newton-Euler formulations 5. Implement joint-based motion planning for robotic manipulators 6. Synthesize control algorithms for motion control of robotic manipulators 	ME2142/ ME3142/ EE3331C	ME2142	Nil	<p>1.Introduction, Spatial Descriptions and Transformations</p> <ul style="list-style-type: none"> • Robot definition • Robot classification • Robotics system components • Notations • Position definitions • Coordinate frames • Different orientation descriptions • Free vectors • Translations rotations and relative motion • Homogeneous transformations <p>2.Manipulator Forward and Inverse Kinematics</p> <ul style="list-style-type: none"> • Link coordinate frames • Denavit-Hartenberg convention • Joint and end-effector Cartesian space • Forward kinematics transformations of position • Inverse kinematics of position • Solvability • Trigonometric equations • Closed-Form Solutions • Workspace <p>3.Mechanics of Robot Motion</p> <ul style="list-style-type: none"> • Translational and rotational velocities • Velocity Transformations • The Manipulator Jacobian • Forward and inverse kinematics of velocity • Singularities of robot motion <p>4.Static Forces and Compliance</p> <ul style="list-style-type: none"> • Transformations of static forces and moments • Joint and End-Effector force/torque transformations <p>5.Robot Dynamics</p> <ul style="list-style-type: none"> • Newton-Euler formulation of manipulator dynamics • Closed-form dynamic equations • Physical interpretation of the manipulator dynamic equations • Lagrangian formulation • Transformations of generalised coordinates <p>6.Trajectory Planning</p> <ul style="list-style-type: none"> • Trajectory planning in joint space • Cubic polynomial for a path (with or without via-points) • Quintic polynomial path • Linear segment with parabolic blends (with or without via points) <p>7.Control of manipulators</p> <ul style="list-style-type: none"> • Independent joint control • Basics of linear control • Control-law partitioning • Modeling and control of a single joint • Control of nonlinear systems • Nonlinear control of manipulators (MIMO) 	Project, Final Examination	<p>Compulsory reading:</p> <ol style="list-style-type: none"> 1. Sciavicco L. and Siciliano B., Modeling and Control of Robot Manipulators. Second Edition (ISBN 1-85233-221-2), Springer Verlag, London, 2000 2. Fu K.S., Gonzalez R.C., and Lee C.S.G. Robotics: Control, Sensing, Vision and Intelligence. McGraw-Hill, NY, 1987. (Recommended for purchase) 3. Sciavicco L. and Siciliano B., Modeling and Control of Robot Manipulators. McGraw Hill, 1996. 4. Craig, J.J., Introduction to Robotics, Mechanics, and Control. 2nd Edition. Addison Wesley, MA, 1989. (3rd Edition, if available) 5. Spong, M.W. and Vidyasagar, M., Robot Dynamics and Control. Wiley, New York, 1989. 6. Paul, Richard P., Robot Manipulators : Mathematics, Programming, and Control : the Computer Control of Robot Manipulators, MIT Press, Cambridge, Mass., 1981. 7. Lewis F.L., Abdallah C.T., and Dawson D.M., Control of Robot Manipulators, Maxwell Macmillan International, 1993.
ME4252	Nanomaterials for Energy Engineering	4	1	<p>This course starts with basics of semiconductors relevant for p-n junction and solar cell devices. Introduces mixed conductors and ionic conductors which are relevant for fuel cells, batteries and supercapacitors. Transport measurements, with an emphasis on impedance studies, will be introduced. The importance of excess surface and interfacial contributions in nanostructured materials and their key roles in modifying thermodynamics and electrical properties will be discussed. Various energy conversion and storage devices (solar cells, fuel cells, batteries and supercapacitors) where the nanosized materials play key roles for improving their efficiencies will be taught. Course will end with remarks on the engineering aspects such as development of energy conversion and storage devices using nanomaterials.</p>	<ol style="list-style-type: none"> 1. Relate semiconductor properties to the underlying physical concepts relevant for various solar cells. 2. Compare energetics and working principles of solar cells, fuel cells and batteries. 3. Recognise role of surfaces/interfaces in nanomaterials for improving the energy conversion and storage processes. 4. Identify and critically evaluate current developments in energy conversion and storage devices. 5. Analyse environmental and economic benefits of nanomaterials for energy engineering. 	Stage 3 or 4 Standing	Nil	Nil	<ol style="list-style-type: none"> 1. Introduction to nanomaterials 2. Introduction to semiconductors 2.1 Carriers in semiconductors 2.2 Carrier concentration 2.3 Intrinsic and extrinsic semiconductors 2.4 Photon absorption and recombination 2.5 Carrier transport phenomena 2.6 Carrier separation 2.7 p-n junction 3. Transport measurements: DC and AC methods 4. Ionic conductors 5. Mixed conductors and defect chemistry. 6. Synthesis and characterisation of single crystals, polycrystalline materials and nanomaterials. 7. Size effects on transport and thermodynamics 7.1 Electrical conductivity 7.2 Thermodynamics 8. Solar energy conversion using nanostructured materials 8.1 Monocrystalline Si solar cells 8.2 Dye-sensitised solar cells 8.3 Perovskite solar cells 8.4 Quantum-dot solar cells. 9. Fuel cells 10. Rechargeable batteries and supercapacitors 11. Engineering aspects of nanomaterials 11.1 Designing miniaturised devices: fuel cells and batteries 11.2 Associated safety issues 	Quiz Mid-term Final Examination	<p>Compulsory reading:</p> <p>Martin A. Green, Solar Cells</p> <p>Supplementary reading:</p> <ol style="list-style-type: none"> 1. J. Maier, <i>Physical Chemistry of Ionic Materials: Ions and Electrons in Solids</i>, John Wiley & Sons (2004)
ME4253	Biomaterials Engineering	4	2	<p>Biomaterials involve the integration of engineering materials with biological entities in the body. The success of any implant or medical device depends very much on the biomaterial used. This course introduces students to life science topics. Students gain an appreciation of multidisciplinary approach to problem solving. Topics include metals, polymers, ceramics and composites use as implants, host-tissue response, materials selection, relationship between structure-composition-manufacturing process, evaluation of implants, sterilization and packaging, regulatory approvals, and suitable case studies. Video presentations and lectures complement the breadth covered in this course. Students enjoy project-based case studies which provoke curiosity, peer evaluation and group dynamics.</p>	<p>On successful completion of this course, the student will be able to:</p> <ol style="list-style-type: none"> 1. Know the different classes of biomaterials 2. Understand regulatory processes for medical implants 3. Understand biocompatibility, wear, stress shielding and corrosion issues in implants 4. Apply materials selection principles in development of medical devices 5. Understand the need to integrate different disciplines to solve biomaterials problems 6. Comprehend the techniques of writing good report. 	Nil	Nil	Nil	<ul style="list-style-type: none"> • Overview of the needs and limitations of materials to repair/replace living tissues/organs • Major classes of biomaterials, their advantages and disadvantages when used as implant materials • Processing routes for the manufacturing of medical devices and how processing affects the materials' properties • Types of failure in implants and reasons for such failure • Performance of various clinical case studies requiring use of replacement devices 	100% CA Essays Project	NA

Course Code	Course Title	Unit	Sem	Course Description	Learning Outcomes	Pre-requisites	Co-requisites	Preclusions	Syllabus	Assessment	Illustrative Reading List
ME4261	Tool Engineering	4	2	All mechanical engineering students need the basic knowledge of metal machining and tool design for mass production and the design of cutting tools. This course provides the fundamental understanding of metal machining and tool design.	On successful completion of this course, the student will be able to: – Identify the types of locators and supports used for jigs and fixtures. – Design a Jig and a fixture – Understand the nomenclature of cutting tools – Design single point cutting tools, drills and milling cutters	Nil	ME2162	Nil	<ul style="list-style-type: none"> Jigs and Fixtures: Work holding principles Locating principles Clamping devices Design of jigs and fixtures for conventional and CNC machines Inspection jigs and fixtures Modular fixtures Mechanics of metal cutting - Chip formation, forces acting on the cutting tool and their measurement, the apparent mean shear strength of the work material, chip thickness, friction in metal cutting, tool life and tool wear Design of Cutting Tools: Nomenclature of cutting tools, Optimisation of tool shape and design features of special single-point cutting tools Conventional drills and milling cutters Grinding wheels and dressing of grinding wheels 	Project Final Examination	NA
ME4262	Automation in Manufacturing	4	2	This course provides a comprehensive introduction to automation technologies applied in discrete part manufacturing. It also introduces essential principles and provides analytical tools for manufacturing control. Major topics covered include: Economic justification of automated systems; Fixed and transfer automation; Automated material handling and automated storage/retrieval systems, Flexible manufacturing systems, Internet-enabled manufacturing, Group technology, Process planning, Automated assembly and Automated operation planning for layered manufacturing processes.	1. Analyse and evaluate the investment alternatives and production cost breakeven. 2. Apply the knowledge in the design and selection of various components needed in automated materials handling, storage/retrieval and layout. 3. Understand the principles of GT, decision making in process planning, RP and how it is applied to process automation. 4. Evaluate the performance measures (average production rate, yield of good assembly, etc) of both multi-station and single-station assembly machines.	Nil	ME2162	Nil	<ol style="list-style-type: none"> Economic justification of automated systems Fixed and transfer automation Automated material handling Automated storage/retrieval systems Flexible manufacturing systems Internet-enabled manufacturing Automated assembly Group technology Computer-aided process planning Automated operation planning for layered manufacturing processes. 	Essays Final Examination	NA
ME4263	Fundamentals of Product Development	4	3	This is an intensive full-time two-week course held during the Special Term covering the following topics relating to the basic product development process: global design perspectives, identifying customer needs and conceptual design, industrial design, design for reliability and product testing, prototyping and design for manufacturing, and product testing economics. Students will propose a product to be developed and work in a team to go through the process via a series of guided exercises relating to the above topics.	On successful completion of this course, the student will be able to: 1. Students will be able to work on a group project on product development by attending interactive classroom sessions. 2. Students will be able to carry out the group project with a final presentation.	Nil	Nil	Nil	<p>Introduction & Global Design Perspectives. Overview of techniques and tools to facilitate and shorten product design and development; emerging trends</p> <p>Identifying Customer Needs Scoping; data gathering and interpretation; prioritizing needs; specification</p> <p>Conceptual Design Concept generation and selection</p> <p>Industrial Design Visualization and communication methods; form design basics; aesthetics; usability</p> <p>Design for Reliability and Product Testing Robust design; related US and Singapore standard</p> <p>Prototyping and Design for Manufacturing Types and uses of prototypes; rapid prototyping technologies; understanding impact of design on manufacturing; basic manufacturability evaluation;</p> <p>Product Design Economics Product economics; net present value base case; sensitivity and trade-off analysis for development decisions; consideration of other quality factors</p>	100% CA - fieldwork, projects	Supplementary reading: "Product Design and Development" by Karl T. Ulrich and Steven D. Eppinger
ME4291	Finite Element Analysis	4	1	This course introduces the fundamental concepts of the finite element method, practical techniques in creating an FEM model, and demonstrates its applications to solve some important stress and thermal analysis problems in Mechanical Engineering. Some necessary background in mechanics will be briefed before the foundations of the FEM theory, concept and procedures are covered. Various formulations and applications to one- two- and three-dimensional problems in solid mechanics and heat transfer will be covered to reinforce the theory and concepts. The precautions in the actual practice of FE analysis such as mesh design, modeling and verification will also be covered. Some instruction in the use of a commercial FEM software package will be given and students are expected to carry out one or more projects with it independently. This course should give students a good foundation for numerical simulation, and basic skills for carrying out stress and thermal analysis for a mechanical system.	1. Define the characteristics and outline the general procedure of Finite Element Analysis (FEA), including scalar field problems. 2. Demonstrate clear understanding of using a FEA software (for example, SOLIDWORKS-Simulation) to conduct engineering analyses on FEA assignments. 3. Explain the different FE formulation approaches to derive the FE models for structural elements, such as 1D truss/bar, and beam elements, and 2D solid elements. 4. Understand and apply the Gauss quadrature rules to evaluate the FE integrals, implement them in basic codes, and solve simple engineering problems.	MA1505 or MA1511 & MA1512	Nil	Nil	<p>Introduction to Numerical Simulations Overview on Numerical Simulations Governing Equations Boundary and Loading Conditions</p> <p>Fundamental of FEA and its Procedures Key Concepts of FEA General Procedures to Create FEM Models</p> <p>FE Formulation for Scalar Field Define Shape Functions Write FE Integral Equations via Weighted Residual Approach Coordinate of Transformations in FE Formulation</p> <p>FEM for 1D Heat Transfer Problems Implementing the FEM for 1D Heat Transfer Problems</p> <p>Practical Issues and Nonlinear FEA FE Modelling Issues, such as meshing, unit consistence Introduction to Nonlinear FEM</p> <p>Hands-on commercial FEM software (e.g. SOLIDWORKS-Simulation)</p> <p>FE Formulations for Solid Mechanics 1D Truss and Beam/Frame Elements 2D Solid Element Energy Method Jacobian of Transformations Gauss Quadrature Rule Numerical Integration</p> <p>Hands-on FEM Coding (e.g. Matlab or Python)</p>	100% CA Projects Mid-term tests	NA