Kingston University London

Mechanical Engineering Modules for Visiting Students 2024/25

Mechanical engineering explore the processes by which mechanical products and systems are designed and manufactured.

Level 4 modules are introductory and provide a solid knowledge of the general technical and non-technical subjects that underpin mechanical engineering practices.

Level 5 introduces more focused studies, covering specialist subjects such as applied mechanics, fluid mechanics, thermodynamics, electronics, control and computing. Students also have the opportunity to extend their mathematics and project-management abilities.

Level 6 modules are advanced and are comprised of core engineering topics and advanced mechanical engineering modules, with a strong focus on independent and group project work.

Updated April 2024/PJW

Entry requirements: GPA of 2.75 or above (out of 4.0) or equivalent

Pre-requisites:

- **Level 4:** prior introductory university-level study of physics/mathematics is very useful.
- **Level 5:** prior study of mechanical engineering topics is required (at level 4 or equivalent).
- **Level 6:** substantial prior study of mechanical engineering is required.
- For levels 5 and 6, any specific pre-requisites for individual modules will be detailed in each module description.

Taught at: Roehampton Vale campus

Notes:

1. All modules are at undergraduate level only.
2. Students enrolled on Study Option 1 are required to study the entire module over both semesters.
3. Whilst the University makes every effort to ensure that this information is correct at the time of updating (April 2024), it cannot accept responsibility for omissions or subsequent changes. Module availability and content may be subject to change, as part of the University's policy of continuous improvement and development.
4. Details of assessment for students enrolled on either Study Option 2 or 3 where provided are **indicative only** and may also be subject to change as part of the above policy.

KEY TO MODULE DESCRIPTORS
SUITABILITY OF MODULE FOR STUDENTS VISITING KU ON STUDY OPTION ____
1: Indicates module is suitable for students visiting KU on Study Option 1 (Whole Year)
2: Indicates module is suitable for students visiting KU on Study Option 2 (Autumn)
3: Indicates module is suitable for students visiting KU on Study Option 3 (Spring)

Kingston University London

Mechanical Engineering Modules for Visiting Students 2024/25

MODULE CODE	TITLE	SUITABILITY		
	LEVEL 4 – INTRODUCTORY			
EG4016	Programming for Engineers	1		3
EG4017	Engineering Mathematics	1	2	
EG4019	Engineering Mechanics and Materials	1	2	
EG4023	Engineering Design and Manufacture	1		
EG4024	Thermodynamics and Fluid Mechanics	1		3
	LEVEL 5 - INTERMEDIATE			
ME5XXX	Numerical Analysis and Computing	1	2	
ME5015	Thermofluids	1	2	
ME5016	Solid Mechanics and Vibration	1		3
ME5017	Electronic and Control Systems	1	2	3
ME5018	Computer-aided Engineering	1		
ME5019	Vehicle Dynamics and Suspension	1	2	
ME5020	Automotive Powertrain Systems	1		3
ME5022	Automotive Design Team Project	1		
	LEVEL 6 – ADVANCED			
ME6012	Mechatronics, Dynamics and Control	1	2	
ME6015	Computational Methods in Engineering and Control	1	2	3
ME6016	Thermofluid and Mechanical Systems 3	1	2	
ME6031	Automotive Systems 2	1	2	3

Study Option 1 = Whole Year
Study Option 2 = Autumn
Study Option 3 = Spring

INTRODUCTORY - LEVEL 4

Module Code	**EG4016**
Module Title	**Programming for Engineers**
Level	4
Prerequisites	None
Credits	4 (US) 7.5 (ECTS)
Suitability	• Open to Study Abroad/International Exchange students for Study Options **1** or **3** • Not open to Erasmus students (as Level 4)
Content	This module is designed to introduce students to scripting in one of the most popular programming languages in industry, which is widely used for data processing, automation of tasks and more recently for machine learning (ML) and artificial intelligence (AI) specifically in the engineering industry. The module has been designed to cover all the fundamentals of programming, which should provide a valuable transferrable skill set that can be fed forward to provide the essential skills needed for scripting in other computer languages in higher-level modules. ➢ **Topics:** • The functionality and operation of an integrated development environment (IDE). • Fundamentals of Object-Oriented Programming (OOP). • Structure and syntax of a program in a language such as Python. • Variables, constants, comments and script formatting. • Basic data structures (Boolean; integer; float; string) and data type conversion. • Inputting data and printing. • Importing functions and modules • Decision structures and looping techniques. • Complex data structures (list; set; dictionary; tuple). • Slicing (lists; strings). • Arrays (1D; 2D; Array methods). • Creating user defined functions. • Plotting data. • Reading and writing to csv files • Classes and methods
Teaching	Lectures, workshops and practical sessions
Assessment	• Portfolio of two computer labs (each lasting one hour), 50% each

Study Option 1 = Whole Year
Study Option 2 = Autumn
Study Option 3 = Spring

Last updated	03/05/24 PJW

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Module Code	**EG4017**
Module Title	**Engineering Mathematics**
Level	4
Prerequisites	None
Credits	4 (US) 7.5 (ECTS)
Suitability	• This module is taught entirely during the **Autumn semester** • Open to Study Abroad/International Exchange students for Study Options **1** or **2** • Not open to Erasmus students (as Level 4)
Content	The aim of this module is to provide a thorough background in engineering mathematics and equip students with the mathematical skills essential for solving engineering problems. The topics introduced will serve as basic tools for studies in many engineering subjects. This comprises algebra, functions, statistics and probability, trigonometry, calculus, differential equations and vectors. Students will be empowered to understand and be able to use the language and methods of mathematics in the description, analysis and design of engineering systems. The emphasis is on using mathematical tools to solve engineering problems. The computing software used will typically include MATLAB and Excel. ➢ **Topics:** • Matrices, vector analysis, trigonometry functions and complex number • Differentiation and Integration: Revision of basic rules and methods for differentiating and integrating a function of one variable, maximum, minimum, points of inflection, and partial differentiation. • Differential equations: First order equations with separable variables, first order linear equations. • Vectors: Addition of vectors, scalar and vector products, applications to three-dimensional geometry. • Statistics and Probability: Mean and standard deviation, regression and correlation. • Numerical Methods: Numerical integration with trapezium and Simpson's rules, Newton's method for solving algebraic equations.
Teaching	Lectures, tutorials and practical sessions

Assessment	• 2 x online maths tests (25% each) • 1 x online maths and computing tests (50%)
Last updated	03/05/24 PJW

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Module Code	**EG4019**
Module Title	**Engineering Mechanics and Materials**
Level	4
Prerequisites	None
Credits	• Full Year: 8 (US) 15 (ECTS) • Single Semester: 4 (US) 7.5 (ECTS)
Suitability	• Open to Study Abroad/International Exchange students for Study Options **1** or **2** • Not open to Erasmus students (as Level 4)
Content	The module introduces students to the fundamentals of structural analysis (statics and dynamics) and the mechanical behaviour of a broad range of engineering materials. The mechanics part provides an understanding of the behaviour of particles and rigid bodies whilst stationary and in motion. Bodies such as trusses in equilibrium are studied and the external and internal parameters including force, moment, stress, or strain are defined and calculated. The analysis of structural components will be developed with theoretical and numerical skills that are necessary in the design of real structures. This section also introduces the dynamics of particles and rigid bodies with their engineering applications. Material test methods will be used to determine the deformations and failures of the various engineering materials. A selection of materials for engineering applications, such as metals, alloys, polymers, and composites, will be studied including their carbon footprint and their impact on the environment. ➢ **Autumn Semester: Materials and Statics** • Mathematical modelling of general engineering problems. • Use of free body diagrams in Statics and Dynamics for analysis of simple structures and machines. • Principle of Statics: forces, resolution of forces and conditions of equilibrium. • Properties of simple structural members: stress and strain, elastic constants, centroids and second moments of area. • Analysis of simple truss and structural components: forces, shear force and bending moment. • Understand and apply the theory of bending in structural engineering and become familiar with axial, shear and bending moment diagrams.

	• Classification and properties of engineering materials: characteristics, analysis, application and evaluation of metals, polymers and ceramics. • Analysis of elastic and plastic deformation and materials hardening. • Introduction to mechanical testing of solids and evaluation of material performance and analysis of failure mechanisms of engineering components. • Principles of material selection procedures and their impact on the environment. • Sustainability issues relating to engineering materials including their carbon footprint, global warming, and its effects. • Laboratory experiments including tensile testing of metals and behaviour of trusses and beams. • The production of succinct laboratory reports: laboratory use, data collection and data analysis using computing methods. ➢ **Spring Semester: Dynamics** • Kinematics of particles with constant and variable accelerations, kinematics of rigid bodies, simple mechanisms. • Kinetics of particles and rigid bodies, Newton's method, energy and impulse • Employability through development of soft skills in written communication.
Teaching	Lectures, tutorials and pc laboratory sessions
Assessment	Study Option **1:** • Group lab report – 3000 words (50%) • MCQ test (50%)
	Study Option **2:** • A version of Study Option 1 assessment
Last updated	03/05/24 PJW

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Module Code	**EG4023**
Module Title	**Engineering Design and Manufacture**
Level	4
Prerequisites	none
Credits	8 (US) 15 (ECTS)
Suitability	• Open to Study Abroad/International Exchange students for Study Option **1** • Not open to Erasmus students (as Level 4)

Content	The principal aim of this module is to provide students with a flavour of what is involved in engineering design and to develop the good academic and professional practice needed to succeed during the course and attain professional status. The module introduces the key aspects involved in planning a project from start to finish, design processes incorporating a sustainability agenda, building an awareness of the interactions across various disciplines, regulatory frameworks and Health and Safety procedures. The module develops good academic and professional practice by developing skills in self-reflection and recording professional development. The basic principles of measurement and manufacturing processes in a workshop and testing environment are also addressed in the module. The module also involves the IMechE Design Challenge as a part of the curriculum, to provide the students with a flavour of how to work in teams to produce engineering artefacts that are capable of accomplishing tasks, as well as developing interpersonal skills in order to enhance the student's employability. ➢ **Topics:** • Mechanical and electrical engineering design processes. • Health and Safety and risk assessment procedures. • Manufacturing using hand and machine tools, metrology and basic CNC principles. • Communication of engineering design ideas through integrating engineering drawing and 3D solid modelling. • Basic electrical theory: AC & DC, electronic components and power supplies. • Analysis of simple linear circuits: parameters, parallel & series, ohms law, energy and power.
Teaching	Lectures, tutorials and hands-on sessions
Assessment	• Workshop Project Portfolio (30 hours) (30%) • Electronics Lab Exercises (6 hours) (30%) • IMechE Design Challenge Prototype (40%)
Last updated	03/05/24 PJW

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Module Code	**EG4024**
Module Title	**Thermodynamics and Fluid Mechanics**
Level	4
Prerequisites	none

Credits	4 (US) 7.5 (ECTS)
Suitability	• This module is taught entirely during the **Spring semester** • Open to Study Abroad/International Exchange students for Study Options **1** or **3** • Not open to Erasmus students (as Level 4)
Content	This module introduces mechanical engineering students to the fundamentals of fluid mechanics and thermodynamics. The fluid mechanics section covers the fundamental properties of fluids along with the main basic conservation equations and their engineering applications. It also introduces the concept of dimensions and the SI units of measurement. Thermodynamics section deals with the relationship between heat and other forms of energy. A variety of topics of engineering and science are dependent on various thermodynamics concepts. You can find applications of thermodynamics everywhere, such as in internal combustion engine or sitting in a room with the air conditioning. The thermodynamics laws that govern the behaviour of various systems will be discussed in depth as they find applications in a variety of disciplines. **Topics:** • In fluid mechanics: properties of fluids, hydrostatics, laminar and turbulent flows, pressure and temperature measurement and three conservation laws: mass, momentum and energy equations together with dimensional analysis will be covered. • For thermodynamics: zeroth, first and second laws of thermodynamics will be introduced with their engineering applications. Units and dimensions, open and closed systems, work, heat, fluid properties in thermodynamics are covered. • Critical thinking and problem solving in fluid mechanics and thermodynamics and effective communication of the solution.
Teaching	Lectures, tutorials and practical sessions
Assessment	3000-word laboratory report (100%)
Last updated	03/05/24 PJW

Module Code	**ME5XXX**
Module Title	**Numerical Analysis and Computing**
Level	5
Prerequisites	Prior study of university-level mathematics such as EG4017 or similar
Credits	4 (US) 7.5 (ECTS)

Suitability	This module runs in the **Autumn** semester Study Options **1** or **2**
Content	This module aims to equip engineering students with mathematical skills that are crucial for comprehending engineering subjects effectively. The topics covered in the module will serve as fundamental tools for studying various engineering subjects. Students will be empowered to comprehend and utilise the language and techniques of mathematics in describing, analysing, and designing engineering systems. The primary focus is on utilising mathematical tools to resolve engineering problems, especially on mechanical systems, robotics, control systems, and signal processing. ➢ **Topics:** Linear Algebra • Matrix Algebra: This topic covers the basic operations of matrices such as addition, subtraction, multiplication, and division. • Linear Equations: This topic covers the solution of systems of linear equations using matrix methods, including Gaussian elimination and inverse matrices. • Determinants: This topic covers the concept of determinants and how to compute them for a matrix. Determinants are used to measure the "size" or "volume" of a matrix, and they have important applications in linear transformations, eigenvalues, eigenvectors, and bases. • Null Space: This topic covers the concepts of null space of a matrix, and its applications especially in robotics. Differential Equations and Laplace Transforms • Introduction to Differential Equations: This topic covers the basic concepts of differential equations, including order, degree, and types of differential equations. • First-Order Differential Equations: This topic covers the solution of first-order differential equations using analytical and numerical methods, including separation of variables, integrating factors, and Euler's method. • Second-Order Differential Equations: This topic covers the solution of second-order differential equations using analytical and numerical methods, including characteristic equations, undetermined coefficients, and Laplace transforms. • Mathematical modelling: These topics covers the techniques to model a system with differential equations. • Laplace Transform: This topic covers the Laplace transform and its applications in solving differential equations. Optimisation • Introduction to Optimisation: This topic covers the basic concepts of optimisation, including optimisation problems, objective functions, constraints, and feasible regions. • Linear Programming: This topic covers linear programming and its applications in solving optimisation problems, i.e., maximise or minimise a linear objective function subject to

	linear constraints. The focus is on linear optimisation problems with a larger number of variables and constraints, using the simplex algorithm. • Nonlinear Programming: This topic covers nonlinear programming and its applications in solving optimisation problems with nonlinear objective functions and/or constraints. The focus is on unconstrained optimisation and optimisation with equality constraints, using gradient-based methods and the Karush-Kuhn-Tucker conditions.
Teaching	Formal lectures, informal tutorials and computing workshops
Assessment	Online computing tests solving problems in Mathematics (100%)
Last updated	03/05/24 PJW

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Module Code	**ME5015**
Module Title	**Thermofluids**
Level	5
Prerequisites	Prior study of fluid mechanics and thermodynamics such as EG4024 or equivalent.
Credits	4 (US) 7.5 (ECTS)
Suitability	• This module runs in the **Autumn** semester • Study Options **1** or **2**
Content	Building on foundational knowledge from introductory (level 4) study, this module dives deeper into thermodynamics and fluid mechanics, exploring boundary layers, heat transfer, and combustion. For internal and external flows involving fluid and solid surface interaction, the boundary layer is an important concept used in particular to determine the drag forces. The main theory behind boundary layers and their engineering applications will be covered. Heat transfer by conduction and convection will also be covered extensively with some example problems. Combustion which is important in many engineering devices such as boilers, furnaces etc. will be discussed in detail. ➢ **Topics:** • A brief revision of the conservation of energy and laws of thermodynamics • Balancing studies • Mechanisms of heat transfer, combustion processes, boundary layers

	• Mixtures of gases • Thermodynamics cycles and their applications to steam power plants, gas turbines, internal combustion engines • Heat exchangers and refrigerators • Problem solving and equation solving techniques • Practical applications
Teaching	Lectures and seminars
Assessment	Portfolio of Two In-Class Tests (3 hours) (100%)
Last updated	03/05/24 PJW

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Module Code	**ME5016**
Module Title	**Solid Mechanics and Vibration**
Level	5
Prerequisites	Prior study of engineering mechanics and materials such as EG4019 or equivalent.
Credits	4 (US) 7.5 (ECTS)
Suitability	• This module runs in the **Spring** semester • Study Options **1** or **3**
Content	This module covers the principles that govern the performance of deformable solids made from various materials under the action of different types of static and dynamic loadings. Design of solid components and structures learned in this module is of crucial importance for solving many engineering problems. In this module, students build on prior study of EG4019 Engineering Mechanics and Materials. The engineering students will be able to design solid components and structures by selecting appropriate materials and geometry. Students learn to compare strength of materials against internal stresses, deformation of materials against internal strains, and response of the systems to dynamic loads. Topics covered in this module include mechanical properties of materials, types of loading, plane-stress and plane-strain conditions, design of beams, torsion of shafts, and buckling. ➢ **Topics:**

	• Understand the fundamental concepts of stress and strain and the relationship between them to solve problems for elastic solids. • Calculate the stress and strain in simple structures. • Analyse and design beams under pure bending and other simple structures. • Solve problems relating to torsional deformation of bars and shafts. • Transformation of stress and strain. • Understand the concept of buckling of columns. • Free vibration of one and two degrees of freedom systems. The module strengthens creative problem-solving, resilience and adaptability through the analysis of complex stress scenarios, fosters a questioning mindset as students tackle inherent indeterminacies, and enhances adaptability with diverse engineering challenges. This is to prepare students for future advancements in mechanics of materials and fundamental of vibration, contributing to an enterprise mindset.
Teaching	Lectures and tutorials
Assessment	2000-word report (100%)
Last updated	03/05/24 PJW

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Module Code	**ME5017**
Module Title	**Electronic and Control Systems**
Level	5
Prerequisites	Prior study of introductory-level mechanical engineering
Credits	• Full Year: 8 (US) 15 (ECTS) • Single Semester: 4 (US) 7.5 (ECTS)
Suitability	• Open to suitably qualified students enrolled at KU for Study Options **1** or **2** or **3**
Content	Due to technological advancements, electronic and control system fundamentals play a vital role across many engineering disciplines. In this module, students will be introduced to the fundamental principles of control system engineering. This module also extends electronics teaching to more complex devices and methods for analysis of electronic circuits. Students will learn how to model and analyse the behaviour of dynamic control systems. Students will understand the concepts of stability and effects of the feedback loop in a control system. Furthermore, students will apply conventional control theory and more advanced artificial

	intelligence-based techniques to solve feedback control problems. MATLAB will be used to reinforce the concepts learned in the module through simulation. This module is technical content rich to enhance analytical as well as employability skills across many engineering disciplines. ➢ **Topics:** • Operational amplifiers and circuit analysis. • Filters, oscillators and monostables. • ADC and DAC signal conversion techniques. • Boolean algebra and logic circuits. • Design and implementation of combinational and sequential logic systems. • Programming microcontrollers. • Interfacing microcontrollers to a range of sensors and actuators. • Mathematical modelling based on ordinary differential equations. • First and second order system analysis. • PID control, stability, Routh-Hurwitz criterion. • Frequency response, analysis and Bode plots. • Laplace Transform and complex numbers. • Computer simulation of system behaviour. ➢ **Autumn Semester: Electronics and Microcontrollers** ➢ **Spring Semester: Control Systems**
Teaching	Lectures, tutorials and pc laboratory exercises
Assessment	Study Option **1:** • Portfolio of In-Class Tests (50%) • Coursework/Practical (50%) Study Options **2/3:** • Part of Study Option assessment
Last updated	03/05/24 PJW

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Module Code	**ME5018**
Module Title	**Computer-aided Engineering**

Level	5
Prerequisites	Prior study of engineering design and manufacture such as EG4023 or similar
Credits	• Full Year: 8 (US) 15 (ECTS) • Single Semester: 4 (US) 7.5 (ECTS)
Suitability	• Study Option 1 only
Content	This module builds on the introductory level engineering design and manufacture, and aims to deepen the knowledge of the mechanical engineers in design communication to British Standard BS8888, from reading engineering drawing to product design specification, design analysis, validation and optmisiation. The traditional design methods are supported by the CAD/CAE software to assist the students in solving and analysing engineering design problems. The digital modelling takes the students from the 2D conventional engineering drawing skills to 3D digital model using feature based and free form modelling techniques. The digital simulation covers two types of analysis, the engineering mechanism design and simulation, finite elements modelling (FEM) and analysis (FEA) using cutting edge solvers. The second part of this module concentrates on the manufacturing stage of the engineering design process. The traditional design for machining and assembly methods are supported by the CAD/CAM software, this assists the students in optimising the design, machining and manufacturing cost. The digital manufacturing takes the students from the conventional methods to 3D digital machining simulation using feature-based recognition for CAD models. The module is structured so that more than 50% of the teaching time is focussed on CAD/CAM/CAE hands-on workshops sessions and practical manufacturing workshops. ➢ **Topics:** • Design Methods: design process, design product specification, solution generation, analysis, evaluation, selection, solution development and testing. • Design and optimisation of engineering elements. • Engineering materials selection, properties, production and form of commonly used materials, cost and application. • Computer Aided Engineering in the design process. Use of detail and assembly drawings in design to comply with current British Standard. • Creation of geometric models, and their use in aiding the effective presentation of design proposals and design simulation. • Product prototyping methods; engineering models; Rapid Prototyping. • Value analysis and engineering. • Design for Manufacture and Assembly – DFMA. • Computer aide manufacture – CAM. • Detail Design and Costing.

Teaching	Lectures, supported by tutorials and hands-on workshops
Assessment	Study Option **1**: • Design Manufacturing Report (2000 words) (50%) • Design Review Test (50%)
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Module Code	**ME5019**
Module Title	**Vehicle Dynamics and Suspension**
Level	5
Prerequisites	Prior study of introductory-level mechanical engineering
Credits	4 (US) 7.5 (ECTS)
Suitability	• This module runs in the **Autumn** semester • Study Options **1** or **2**
Content	The module introduces basic principles of automotive suspension and chassis systems of modern vehicles and race cars. It is delivered through a project-based approach, including lectures, tutorials and practical laboratory sessions. The module starts with the dynamics of high performance road vehicles and race cars, relating quantitative data to power and efficiency performance characteristics. It also introduces elements of suspension and chassis design. Apart from component identification, emphasis is put on preliminary calculations related to the introduced systems. Students will develop a questioning mindset and creative problem-solving skills as they delve into the principles of suspension systems and the design and structural analysis of a chassis. The complexity of these topics encourages critical thinking and innovative solutions. Digital competency will be enhanced through the study of current developments in autonomous technology, providing a solid foundation for adapting to the evolving digital landscape of automotive engineering. Practical activities and tutorials encourage collaboration, enabling students to work together effectively. Resilience is fostered as students tackle challenging calculations and kinematics related to on-track performance. ➢ **Topics:** • Principles of suspension systems

	• Suspension performance calculations and kinematics related to on track performance. • Introduction to design and structural analysis of a chassis.
Teaching	Lectures and seminars
Assessment	• Scale Vehicle Performance Report (1800 words) (60%) • In-Class Test (lasting two hours) (40%)
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Module Code	**ME5020**
Module Title	**Automotive Powertrain Systems**
Level	5
Prerequisites	Prior study of introductory-level mechanical engineering
Credits	4 (US) 7.5 (ECTS)
Suitability	• This module runs in the **Spring** semester • Study Options **1** or **3**
Content	The module introduces basic automotive systems of modern vehicles and race cars. It is delivered through a project-based approach, including lectures, tutorials and practical laboratory sessions. The module introduces Internal Combustion (IC) engines and electric powertrains, as well as autonomous vehicle technology. It also introduces elements of design and simulation of these systems and optimization for both high performance and high efficiency applications. The systems will be reviewed from a theoretical and mathematical basis, in conjunction with practical laboratory exercises for validation and further reinforcement of working principles. ➢ **Topics:** • Working principles of Internal Combustion Engines (ICE) and how they can be tuned for efficiency and/or high performance. • Engine performance calculations and thermodynamics related to engine cycles. • Introduction to electric motors and control electronics. • Principles of electric and combustion powertrain systems. • Introduction to emerging electric, hybrid and alternative fuels vehicle technology.

Teaching	Lectures, tutorials and practical laboratory sessions
Assessment	Portfolio of ICE Power Analysis Electric Powertrain Report (1500 words each) (100%)
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Module Code	**ME5022**
Module Title	**Automotive Design Team Project**
Level	5
Prerequisites	Prior study of introductory-level mechanical engineering
Credits	• Full Year: 8 (US) 15 (ECTS) • Single Semester: 4 (US) 7.5 (ECTS)
Suitability	• Study Option **1** only
Content	This module is a core module for Mechanical Engineering (Automotive) BEng students and forms a strong foundation with regards to team-based design work. Industry standard software and design principles are taught alongside a project-based assessment regime to produce robust and quality outputs which will help prepare students for Level 6. Each year will involve a different automotive subsystem design towards which the student will work in groups to produce a technical report covering design, CAD, cost and manufacturing details. British standards will be applied to prepare students for industrial practice and increase employability in the engineering sector. A design report and group presentation are used as assessment methods with regular project reviews to help develop ideas and best practices. ➢ **Topics:** • Development of 3D CAD parts of automotive sub systems. • Produce technical drawings that adhere to industry standard BS8888 and others. • Consider design for manufacture and design for assembly principles in technical component design. • Be able to analyze the cost breakdown of specific manufacturing techniques. • To be able to communicate technical documentation and projects in a presentation.
Teaching	Lectures, supported by tutorials and hands-on workshops

Assessment	Study Option **1**: • 3000-word engineering team project report (40%) • 1000-word technical cost report (30%) • Engineering Project Presentation (30%)
Last updated	03/05/24 PJW

LEVEL 6 – ADVANCED

Module Code	**ME6012**
Module Title	**Mechatronics, Dynamics and Control**
Level	6
Prerequisites	• Substantial prior study of intermediate-level mechanical covering mechanics, electronics, control, microcontrollers and computing such as ME5012 and ME5011
Credits	• Full Year: 8 (US) 15 (ECTS) • Single Semester: 4 (US) 7.5 (ECTS)
Suitability	• Open to suitably qualified students enrolled at KU for Study Options **1** or **2**
Content	This module enables students to identify and develop skills in the solution of problems relating to electromechanical design in mechatronics products. On the one hand, the students develop skills to solve, model and interpret dynamics behaviour of structures and systems. On the other hand it introduces to students how embedded microprocessors may be used to sense, process and control real world events, The module covers topics such as modelling of multi degree of freedom of vibrating systems, natural frequencies, damping, mode shapes, response due to various excitations, graphical tools for control systems, transient response, gain control, cascade compensations, sensors and actuators, and their signal conditioning, microcontroller programming and use of related software such as MATLAB and microcontroller specific software. **Overall content:** • Free and forces vibration analysis of multi degree of freedom systems. • Use of MATLAB to solve structural dynamics problem, eigen functions. • Modal testing, theory and practice. • Roots locus techniques, design of compensators.

- Sampled data control systems, z-plane.
- Analogue and Digital Sensors.
- D.C. Motors and Stepper Motors
- Signal Conditioning Circuits
- Servo Amplifier, PWM amplifier and H bridge
- ADC and DAC
- Peripheral Interface Adapter
- High level program development for system integration
- Noise
- Computer communication

Autumn Semester: Microcontrollers; Sensors and Actuators

The Arduino Microcontroller

- Review of the Arduino microcontroller; Using a virtual development environment to create circuits and sketches
- Pull-up & Pull-down resistors; Port manipulation; Functions
- Functions; Mapping function; Servo motors
- Interrupts; Capacitive Sensors
- Liquid Crystal Displays
- Ultrasonic range sensors; Relays & MOSFETs
- Stepper Motors

Sensors and Actuators

- Introduction to Sensors and Actuators
- Number System & Signal Convertors (ADC & DAC)
- Digital Sensors
- Analogue Sensors
- Actuators and Electromagnetism
- Short Stroke Actuators and Brushed DC Motors
- Brushed DC Motor Drive Electronics
- Brushless AC Motors and AC Motor Control
- Brushless DC Motors
- Stepper Motor

➢ **Spring Semester: Control and Dynamics**

- Control Systems: Performance in Time Domain (Design Specs.)
- Control Systems: Root Locus Analysis
- Control Systems: Root Locus Design
- State Space: State Analysis
- State Space Design, Pole Placement

	• System Dynamics: Multi-Degrees of Freedom Dynamic Systems
Teaching	Lectures, seminars, practical sessions
Assessment	Study Option **1:** • In-class test – 1 hour (30%) • Coursework: Sensors and Actuators: 1,200-word report (20%) • 2.5-hour exam (50%)
	Study Option **2:** • In-class test – 1 hour (60%) • Coursework: Sensors and Actuators: 1,200-word report (40%)
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Module Code	**ME6015**
Module Title	**Computational Methods in Engineering and Control**
Level	6
Prerequisites	• Substantial prior study of intermediate-level mechanical covering mechanics, electronics, control, microcontrollers and computing such as ME5012 and ME5011
Credits	• Full Year: 8 (US) 15 (ECTS) • Single Semester: 4 (US) 7.5 (ECTS)
Suitability	• Open to suitably qualified students enrolled at KU for Study Options **1** or **2** or **3**
Content	This module combines elements of analytical techniques and computational methods used in solving engineering problems. The analytical techniques concern Structural Mechanics, Thermofluids, Multidegree of Freedom Vibrating Systems and Multivariable Control Engineering. The computational methods concern the analysis of a structure using the Finite Element Analysis (FEA), the analysis of internal and external flows, as well as heat transfer, using Computational Fluid Dynamics (CFD), modelling and simulation of multidegree of freedom vibrating systems using MATLAB/SIMULINK, and the analysis of multivariable control engineering for mechanical/electromechanical systems using Experience Controls App and

	MATLAB/SIMULINK. To this end, this core module also includes the use of industry-standard software and High Performance Computing (HPC) for the analysis of basic engineering systems. **Overall content:** • Introduction to Finite Element Analysis (FEA). • Direct stiffness method. • Weighted residuals methods. • Variational methods of approximation. • Strong and weak formulations of a problem. • Introduction to time dependent problems. • Finite element method programming. • Introduction to Computational Fluid Dynamics (CFD). • Use of commercial software in FEA and CFD for the analysis of engineering problems. • Finite Difference approximation for 1st and 2nd order partial derivatives. • Equilibrium and equation of motion of a continuum. • Finite Difference solution of PDEs. • Analysis of the stability of numerical solution. • Finite Volume approximation for 1st and 2nd order partial derivatives. • High Performance Computing (HPC) and application in CFD. • Dynamics and vibration of multi-degree-of-freedom systems. • Use of industry-standard software to solve structural dynamics problem and controllers design. • Modal testing, theory and practice. • Roots locus techniques, design of compensators. • Pole Placement and Linear Quadratic Regulator techniques, design and tuning. **Autumn Semester: Finite Element Analysis (FEA); Computational Fluid Dynamics (CFD)** **FEA:** • Introduction to finite element method • Direct stiffness method - Spring element • Direct stiffness method - Bar element • Direct stiffness method - Beam element • Weighted residuals methods • Galerkin method **CFD:** • Fundamentals of CFD • Numerical Solution of Fluid Equations • Finite Difference Method • High Performance Computing (HPC) • Finite Difference Method

	• Finite Volume Method **Spring Semester: Control and Dynamics** • Control Systems: Performance in Time Domain (Design Specs.) • Control Systems: Root Locus Analysis • Control Systems: Root Locus Design • State Space: State Analysis • State Space Design, Pole Placement and LQR • State Space: Observers Design, Observers Design, LQE • State Space: Linear Quadratic Gaussian Control Gaussian Contr • System Dynamics: Multi-Degrees of Freedom Dynamic Systems
Teaching	Lectures, seminars, practical sessions
Assessment	Study Option **1:** • Coursework 1 Part A - FEA of Plate with a Hole (30 pages max) (10%) • Coursework 1 Part B - CFD analysis of a full scale car (10%) • Coursework 2 - Control Design of Feedback Controllers (20%) • Three-hour exam (60%)
	Study Option **2:** • In-class test – 1 hour (60%) • Coursework: Sensors and Actuators: 1,200-word report (40%)
	Study Option **3:** • Coursework - Control Design of Feedback Controllers
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Module Code	**ME6016**
Module Title	**Thermofluid and Mechanical Systems 3**
Level	6
Prerequisites	Completion of intermediate-level module ME5011 or equivalent
Credits	• Full Year: 8 (US) 15 (ECTS)

	• Single Semester: 4 (US) 7.5 (ECTS)
Suitability	• Open to suitably qualified students enrolled at KU for Study Options **1** or **2**
Content	This module builds on the knowledge gained in the intermediate level ME5011 Thermofluids & Mechanical Systems 2 module to extend students' knowledge and skills in structural analysis based on fracture mechanics and fatigue. Simulation will be used to give a practical introduction to the finite element analysis (FEA) method for structural analysis. Thermofluids mechanics aspects involving conversion and transfer of energy such as turbomachines (pumps, turbines…) and heat exchangers will be discussed. The module also provides a further understanding of numerical methods employed in fluid flow and heat transfer analysis using computational fluid dynamics (CFD). **Overall content:** • Introduction to finite element theory and applications. • Three dimensional Hooke's law for stress and strain, stress concentration at discontinuity. • Fracture mechanics theory and experimental methods. Crack opening displacement methods. Fatigue crack initiation and propagation. Low and high cycle fatigue. Surface condition and microstructure. Life prediction, statistical methods. • Thin and thick-walled cylinders with internal pressure loading. Interference fits. Plastic failure. Rotating cylinders. • Creep and stress relaxation. Advanced composites. Adhesives and coatings. • Subsonic and supersonic flows with application to flow in nozzles and ducts. Determination of flows, areas and thrusts. • Water hammer and surge, methods of analysis. Application of numerical, graphical and computer methods. • Skin friction in laminar and turbulent boundary layers. Applications to forces on surfaces • Performance characteristics, isolated blade and cascades, cavitations. Applications to forces on surfaces. • Performance characteristics, isolated blade and cascades, cavitations. Application to series and parallel operation, selection and system machine. • General heat conduction equation, numerical solutions, fin theory, transient heat transfer. Applications. Convection, natural, mixed and forced. Heat transfer coefficients, heat exchanger design. Radiation and furnace design. • Gas and vapour mixtures, hygrometry. Application to plant systems vapour and gas power cycles. • Introduction to the fundamental concepts and techniques used in Computational Fluid Dynamics (CFD) with practical application using commercial software. ➢ **Autumn Semester: Structural Analysis; Fluid Mechanics and Heat Transfer** **Structural Analysis** • Introduction to fracture mechanics- Elasticity, Design Philosophy, 3-Dimensional Stress

	States, Plane stress and plane strain states • Mohr's circle, Stress Intensity Factor, Mode-I, II and III stress and displacement fields • LEFM- Relation between SIF and the energy release rate. Experimental measurement of fracture toughness, plastic zone size around crack tip. • Introduction to fatigue failure. S-N diagram, stages of fatigue crack growth. • Fatigue Crack Growth: Paris law and associated modified methods **Fluid Mechanics and Heat Transfer** • Compressible Flows – Basic Equations • Mechanisms of heat transfer and heat diffusive equation. • Compressible Flows – Isentropic relations, Nozzles operating characteristics • Conduction heat transfer (analytical and numerical methods). • Compressible Flows – Shock waves in nozzles • Conduction heat transfer (extended surfaces). ➢ **Spring Semester: Structural Analysis; Fluid Mechanics and Heat Transfer** **Structural Analysis** • Solution of problems in LEFM and EPFM • Design of cylindrical and spherical pressure vessels • Leak-Before-Break (LBB) criterion. Solution of problems on design of pressure vessel based on fracture criterion • Thick cylinders with internal pressure loading **Fluid Mechanics and Heat Transfer** • Rotodynamic Machines–Axial, radial systems, Euler equations • Forced convection • Rotodynamic Machines- Performances - Fluid Transient introduction • Free convection design • Heat exchangers • Phychrometry • Fluid Transient in pipes-Water hammer
Teaching	Lectures, tutorials, computing workshops
Assessment	Study Option **1:** • Group Assignment 1 Part A: Failure Assessment, Finite Element Analysis and Computational Fluid Dynamics – 4,000 word report (20%) • Group Assignment 1 Part B: CFD aerodynamics of a fighter jet. – 2,000-word report (10%)

Study Option 1 = Whole Year
Study Option 2 = Autumn
Study Option 3 = Spring

	• Individual assignment: application of thermofluids in rotodynamic machines and heat transfer – 30 pages (20%) • 3-hour exam (50%)
	Study Option **2:** • Group Assignment 1 Part A: Failure Assessment, Finite Element Analysis and Computational Fluid Dynamics – 4,000-word report • Group Assignment 1 Part B: CFD aerodynamics of a fighter jet. – 2000-word report
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Module Code	**ME6031**
Module Title	**Automotive Systems 2**
Level	6
Prerequisites	• Completion of ME5031 Automotive Systems 1
Credits	• Full Year: 8 (US) 15 (ECTS) • Single Semester: 4 (US) 7.5 (ECTS)
Suitability	• Open to suitably qualified students enrolled at KU for Study Options **1** or **2** or **3**
Content	The module content spans across various areas of automotive design, simulation and optimization. In the autumn semester, the focus is on the former, while building students' awareness and technical abilities in both computer aided design and finite element analysis packages (SolidWorks and ANSYS respectively). In the spring semester the focus shifts towards fluid simulation and aerodynamics, allowing students to optimise vehicle geometry for efficiency and power applications. ➢ **Autumn Semester: Introduction to Engineering Design; Computer Aided Design (CAD)** **Introduction to Engineering Design** • Introduction to vehicle design • Geometric Descriptors and Tolerances • Geometric Dimensioning and Tolerances • Failure Mode and Effect Analysis (FMEA)

Study Option 1 = Whole Year
Study Option 2 = Autumn
Study Option 3 = Spring

	• Design Methodologies - System Design Specification (SDS) and System Design Evaluation **Computer Aided Design (CAD)** • Introduction to CAD • CAD Environments and Assembly Processes • Tolerancing and Technical Drawing **Finite Art Analysis** • Using ANSYS to perform analysis on various automotive based three dimensional models, including assemblies and parts used on the KU20 formula student vehicle. ➢ **Spring Semester: Introduction to Computational Fluid Dynamics (CFD); Automotive Aerodynamics** **Introduction to CFD** • Using the concept of computational fluid dynamics (CFD) techniques and using commercial CFD software to solve engineering problems. **Automotive Aerodynamics** • Vehicle Aerodynamics • Aerofoil Geometry, Aerodynamic Forces & The Boundary Layer • F1 Wings, Wing Tip Vortices and Induced Drag & Technology • Ground Effect and Underbody Tunnels, F1 Components, Drag Reduction and Design • Wind Tunnel Testing, CFD and Formula Student
Teaching	Lectures, seminars, practical sessions
Assessment	Study Option **1:** • Assignment 1: CAD/FEA engineering technical report -1,200 words (15%) • Assignment 2: Dynamometer testing lab report – 800 words (10%) • Assignment 3: external CFD analysis of a FS car (15%) • Three-hour exam (60%)
	Study Option **2:** • CAD/FEA engineering technical report - 1,200 words
	Study Option **3:** • Portfolio of assignments

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