School of Engineering

Study Abroad Module Handbook

2024-2025

Table of Contents

[Year 1 2](#_Toc68149453)

[Electronic, Electrical & Systems Engineering 11](#_Toc68149454)

[Mechanical Engineering 35](#_Toc68149455)

[Civil Engineering 55](#_Toc68149456)

[Railway Engineering 78](#_Toc68149457)

[Integrated Design Projects 88](#_Toc68149458)

# Year 1

**Module Title:** Engineering Mathematics 1

**Module Code:** 27887

**Semester:** 1

**Credits:** 20

**Level:** LC

**Module Description:** The module aims to enhance student knowledge and understanding of the mathematics used in Engineering and to develop the skills of its use.

* Exponentials, logarithms and hyperbolic functions
* Trigonometry
* Differentiation
* Integration
* Taylor's and Maclaurin's series
* Vector Algebra
* Complex Numbers
* Differentiation of implicit, trigonometric and parametric
* Functions: Ordinary differential equations
* Matrices and determinants
* Mathematical foundations of numerical methods

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**Module Title:** Introduction to Computing for Engineers

**Module Code:** 28607

**Semester:** 1

**Credits:** 10

**Level:** LC

**Module Description:** The aim of this module is to introduce engineers to computers and computer programming using an important modern programming language which has applications from small embedded systems to supercomputers. Syllabus Lecture material:

1. Introduction to Computer Programming
   1. Key definitions - components of a computer, operating system, embedded computers.
   2. High-level programming languages - overview and examples
   3. C programming language - history, current importance and applications
   4. Compiling and Linking
2. Introduction to C programming
   1. Variables & Data types
   2. Assignment and initialisation
   3. Operators & Input
   4. Introduction to using the Math library
3. Program control (Iteration & Selection)
   1. Loops - importance in programming
   2. Iteration - "for" loops, The "while" loop, The "do - while" loop, and Comparison of for, while and do-while loops
   3. Conditional statements - the "if" and "if else" statements
   4. The switch statement
   5. Logical and relational operators
4. Arrays
   1. Introduction to arrays - rationale for using arrays in C
   2. Declaring arrays, Initializing arrays, Multi-dimensional arrays, and Character arrays – strings.
5. Functions and procedural programming
   1. Basic ideas about functions
   2. Local, global and static variables
   3. Function arguments and "call-by-value"
   4. Function prototypes
6. Introduction to numerical methods and algorithms
   1. Developing mathematical / numerical applications
   2. Internal representation of data types and Variable precision - roundoff errors
   3. Algorithm expression and design
7. Files
   1. Files - the basics, Using files - the FILE data structure
   2. String file i/o - fgets() and fputs() and Formatted file i/o - fprintf() and fscanf()
8. Pointers
   1. Concept of pointers as memory addresses
   2. Pointer and indirection operators, pointer arithmetic
   3. Pointers and arrays, Pointers and functions - call by reference
   4. Dynamic allocation of one-dimensional arrays
9. Real-world applications
   1. Introduction to program design
   2. Header files and libraries
   3. Developing new data types - "structs" and "typedefs"
   4. Programming on Embedded systems.

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**Module Title:** Mechanics 1

**Module Code:** 28608

**Semester:** 1

**Credits:** 20

**Level:** LC

**Module Description:** The aim of the module is to enhance students’ knowledge of the principles of mechanics and some essential mathematics and show how they can be used to solve problems.

Syllabus

* Vectors (including dot product), kinematics: displacement, velocity and acceleration
* Newton’s laws of motion: momentum (including collisions) and force (including friction)
* Work, power, kinetic and potential energy
* Centre of mass
* Motion in a circle: kinematics, centripetal force, torque (including cross product of vectors), moment of inertia (including the parallel & perpendicular axis theorem)
* Conditions for equilibrium, including applications to simple machines
* Mechanics of materials: stress (including shear), strain, elastic moduli, strain energy, torsion of shafts, bending of beams (including second moment of area)
* Stresses due to elastic and plastic bending (including neutral plane)
* External & internal forces (including distributed loads, Uniformly distributed & Linearly varying forces)
* Pin-jointed trusses
* Statically determinate & indeterminate problems (principle of superposition; including temperature Stresses)
* Deflections of beams
* Discontinuous bending moment functions
* Plastic analysis

Regarding practical work, students will be expected to demonstrate the ability to use the results of mechanical analysis to solve engineering problems and to recommend appropriate action.

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**Module Title:** Integrated Design Project 1A

**Module Code:** 33283

**Semester:** 1

**Credits:** 10

**Level:** LC

**Module Description:** The aim of the module is to introduce students to the design process and the skills employed therein, within an engineering context.

There are three elements to the module and the following will be covered:

1. Professional Skills: report writing, literature searching, presentation skills, team working;
2. Design Process: product design specification, concept design, selection of concept designs, detail design;
3. Drawing: sketching, engineering drawings, computer aided design.

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**Module Title:** Electrical Engineering 1

**Module Code:** 28604

**Semester:** 2

**Credits:** 20

**Level:** LC

**Module Description:** In this module, the fundamentals of electronic and electrical engineering are covered. It will begin with analogue circuits describing the fundamentals of circuit analysis and the design of analogue devices. The fundamentals of digital systems will then be covered using Boolean algebra and related techniques to analyse digital circuits up to an introduction to flip flops. Finally, electrical power and machinery systems will be introduced.

Syllabus

Analogue Circuits

Analysis of circuits:

* Basic circuit variables and sources
* Impedance, resistance, reactance, Ohm’s law and terminal equations of resistors, capacitors and inductors, phasor description by analogy with vectors.
* Series and parallel connections, voltage and current division and duality
* Kirchoff’s laws
* Mesh analysis and nodal analysis directly and with matrices
* Thevenin’s and Norton’s theorems
* Maximum power theorem
* Resonance

Design of devices by applying circuit laws:

* Diodes in polarity protection and power-on indicators
* Inverting op-amp amplifier
* Differential op-amp amplifier
* Application of sources, LED indicators, diode protection and op-amp in a 4-point resistance measurement from a strain gauge applicable to a model bridge

Digital Systems

* Introduction to data types: rational, irrational, integer and binary numbers.
* Variable representing binary signals.
* Combinations of binary variables (bits and words)
* Representations of integer and fractional numbers using binary bits: emphasis that all representations are simply bit-patterns.
* Stimuli of multi-bit inputs.
* Truth tables.
* Introduction to basic logic gates: AND gates, OR gates and Inverters, symbols, truth tables and Boolean equation representation.
* Circuit diagram representation of Boolean equations, Boolean equation representation of circuits.
* Canonical, sum-of-product representation of circuits and equations.
* Basic rules of Boolean algebra minimisation of Boolean equations by algebraic manipulation.
* The K-map.
* Boolean minimisation by use of the K-map.
* Introduction to the concepts of space and time relating to Boolean variables (functions of time).
* Introduction to Set-Reset, D-type, T-type and JK flip-flops, described via timing waveforms and transition tables.
* Conversion of flip-flops to other forms of flip-flops.
* Simple counters and shift-registers (if time permits).

Electrical Power and Machines:

* Magnetic Circuits
* Magnetic Fields, Circuits and Materials, Transformers, Inductors
* DC Machines Theory and Operation
* Power in reactive circuits, power factor
* RMS values
* Diode based Rectifier
* Three Phase Systems and power

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**Module Title:** Engineering Materials (managed by Met & Mat)

**Module Code:** 28605

**Semester:** 2

**Credits:** 10

**Level:** LC

**Module Description:** The aim of the module is to introduce the range of materials and their key properties used in engineering in order to allow them to select the appropriate materials for a given application. The module also introduces fundamental science that determines the electrical or mechanical properties of materials, such as atomic / molecular structures. In addition students will also be introduced to software which will allow them to model the properties and behaviour of engineering materials and analyse the results of experiments.

Syllabus: Lecture material

1. Introduction
   1. Classification of materials into key groups based on chemistry and structure on different levels: metals, ceramics, polymers, composites, glasses and liquids
   2. Identification of key physical properties affecting materials selection: Elasticity, deformation, failure and conductivity.
2. Basic Science:
   1. Simple mechanics
      1. Newton’s laws, Work done, Kinetic and potential energy
      2. Elasticity and Hooke’s law
   2. Simple electrostatics
      1. Definitions of electric field, electrostatic potential and forces
      2. Visualisation of electric fields using electric field lines.
      3. Gauss's flux law
      4. Electric field within a parallel plate capacitor
3. Atomic structure and material properties
   1. Atomic orbitals and types of bonding
   2. Structure of engineering materials, packing in metals and ceramics, molecular chains in polymers)
   3. Insulators, semiconductors, metals
   4. Bonding and Hooke’s law
4. Deformation and mechanical failure
   1. Tensile testing and hardness measurement
      1. Methods
      2. Yield point and peak stress
      3. Ductile tearing versus brittle fracture
   2. Young’s modulus and stiffness
   3. Hardness, plastic deformation and dislocations
      1. Dislocations and slip
      2. Force on dislocation due to shear stress and dislocation energy
      3. Dislocation pinning and precipitate hardening
   4. Toughness and fracture
      1. Toughness and strain energy release rate
      2. Crack growth and critical length.
5. Conductivity and currents
   1. Motion of charges in an electric field
   2. Motion in vacuum
   3. Motion in a solid
   4. Mobility
   5. Definition of current and current density
   6. Sign conventions
   7. Resistivity and conductivity
   8. Ohm's law in microscopic and macroscopic form
6. Definition and measurement of whole life issues
   1. Fatigue
   2. Work hardening

Syllabus: Computer based exercises

Introduction to data analysis using mathematical computing software.

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**Module Title:** Fluid Mechanics and Energy Transfer

**Module Code:** 28606

**Semester:** 2

**Credits:** 20

**Level:** LC

**Module Description:** In this module, the fundamentals of fluid mechanics and energy conservation, and introduce associated engineering applications.

Syllabus.

Fluid Mechanics:

* Introduction to fluid flow phenomena in engineering.
* Hydrostatics: Pressure variation with position in a static fluid, manometers, hydrostatic forces on submerged surfaces, forces on unconstrained bodies.
* Hydrodynamics: classification of flows in terms of variation of flow parameters in time and space, the concepts of streamline and stream tube, the principles of continuity, energy and momentum, turbulent flow.
* Applications of principles to engineering problems, including flow measurement by orifice, Venturi, Pitot tube, rotameter & weirs. Forces on pipe bends, nozzles and plates.
* Physical fluid properties, their dimensions and units, SI System, dimensional analysis.

Energy Conservation Principles:

* Conduction: (one-dimensional steady state) Fourier’s Law, conduction with multiple layers, simple geometries, resistance in series.
* Convection and Boundary Layers: transfer coefficients for natural and forced convection. Practical problems involving forced convection, resistances in series, overall transfer coefficients.
* Basics of radiation: (Stefan-Boltzmann equation), emissivity, absorptivity, transmissivity and reflectivity, net exchange of radiation between surfaces.
* The scope of thermodynamics. The basic quantities and their SI units. The fundamental concepts: force, pressure, temperature, intensive and extensive properties, the system and its surroundings, closed and open systems, state and processes, phases and components, phase changes and equilibrium, and the different forms of energy.
* First Law. The energy balance equation and its applications to closed and open systems. The continuity equation. Work and heat in processes. Reversible and irreversible processes. Heat engines. Carnot cycle and some other theoretical cycles including refrigeration.
* Second Law: Entropy and irreversible processes, spontaneous processes.

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**Module Title:** Integrated Design Project 1B

**Module Code:** 33248

**Semester:** 2

**Credits:** 10

**Level:** LC

**Module Description:** The aim of the module is to introduce students to the design process and the skills employed therein, within an engineering context.

The work develops themes introduced in Integrated Design Project 1A. It consists of the following three elements:

* A team design, build and test project, which includes: re-designing a structure (designed in Integrated Design Project 1A), building the structure to the drawings and mechanical testing.
* An introduction to the patent system and intellectual property rights to provide a basic understanding of how product designs, as intellectual property, are protected, impact of ethics and sustainability.
* A team design project for a topic specific application (supported by introduction sessions)\*, which includes: producing a design specification, undertaking a patent search, producing a range of concept designs, selecting an appropriate concept, producing a detail design.

In the weeks allocated for post-examination courses, students will undertake discipline specific training. Where appropriate students will undertake a site visit related to their specific disciplines.

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# Electronic, Electrical & Systems Engineering

**Module Title:** Communications Systems

**Module Code:** 13812

**Semester:** 1

**Credits:** 10

**Level:** LI

**Module Description:**

1. INTRODUCTION TO COMMUNICATION SYSTEMS
   1. Wired transmission lines
   2. Wireless communications
2. INFORMATION THEORY
   1. Shannon's theory
   2. Channel capacity
   3. Effect of noise on digital signals.
3. DIGITAL BASEBAND TRANSMISSION
   1. Fourier transforms: Revision
   2. Baseband signals and spectra
   3. Random digital waveform, PSD
   4. Baseband noise.
   5. Probability of error.
   6. Sampling and Quantisation; Nyquist rate
   7. Quantisation noise
4. FILTERS
   1. Chebyshev passive LC filters
   2. Synthesis from tables
   3. Frequency and magnitude scaling
5. PASSBAND SIGNALS AND SPECTRA
   1. Analogue AM, FM waveforms and their spectra
   2. Digital (binary) waveforms: ASK, PSK, FSK ,and their spectra
   3. Complex envelopes.

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**Module Title:** Multidisciplinary Systems and Software Engineering

**Module Code:** 29903

**Semester:** 1

**Credits:** 10

**Level:** LI

**Module Description:** This module will introduce engineering students to the emerging field of multidisciplinary system and software engineering. Students will attain knowledge of the following skills:

* Identify Requirements Needs (Functional, Performance, and Quality)
* Create systems/software architectures that integrate together
* Define rules and Performance for external and internal interfaces
* Define non-functional requirements
* Define and execute overall system verification and validation
* Manage system changes
* Manage system risks
* Manage system/software processes
* Perform systems vs. software trade-offs.
* Develop/Derive/Allocate Detailed Low-Level Requirements
* Define formal coding methods
* Define Software Processes, Methodologies and Tools
* Define Reuse vs New Development Tradeoff criteria
* Customer Interfaces
* Defining Software Quality Attributes
* Determine coding Methodology
* Define Software Verification and Validation Methodology
* Software Engineering Management
* Application of Computational Analysis and Thinking.

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**Module Title:** Electronic Circuits and Devices and Electromagnetics

**Module Code:** 19505

**Semester:** 2

**Credits:** 20

**Level:** LI

**Module Description:** Students deepen their understanding of electronic circuits, with a more in-depth consideration of linear circuits examination of non-ideal effects, and consideration of nonlinear circuits. They are introduced to transistor based amplifier circuits. Students are introduced to the origin of the behaviour of solid state electronic devices. Students are introduced to electrostatics and magnetostatics.

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**Module Title:** Digital Electronics and Electrical Machines

**Module Code:** 34565

**Semester:** 1

**Credits:** 20

**Level:** LI

**Module Description:**

Embedded systems

* Design and implement complex synchronous and asynchronous digital systems
* Design synchronous finite state machines
* Implement synchronous finite state machine using logic devices

Electrical Power Systems

* ac to dc conversion
* dc to ac conversion
* Transformers
* Important principles, such as non linear power, rotating magnetic field and fourier analysis
* Advanced dc motors
* ac motors
* Power systems

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**Module Title:** LI Electrical Energy Systems and Control A

**Module Code:** 34510

**Semester:** 1

**Credits:** 10

**Level:** LI

**Module Description:**

Semester 1: Electrical Power Systems

1. AC TO DC CONVERSION.
2. DC TO AC CONVERSION.
3. TRANSFORMERS.
4. IMPORTANT PRINCIPLES, such as non linear power, rotating magnetic field and Fourier analysis
5. ADVANCED DC MOTORS.
6. AC MOTORS.
7. POWER SYSTEMS.

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**Module Title:** Microprocessor and Control Systems

**Module Code:** 34566

**Semester:** 2

**Credits:** 20

**Level:** LI

**Module Description:**

Embedded systems

* Write programs for embedded microcontrollers, and interface the microcontroller to support circuitry;
* Design interfacing circuity for communication between microprocessors and peripherals;
* Write C programmes for embedded microcontrollers that control peripheral hardware

Control Engineering

* Introduction to Control Engineering
* Control fundamentals: modelling of simple mechanical and electric systems, analysis of systems, steady state error analysis, stability (Simplified Nyquist), stability margins.

Control Design

* Design based-upon Nichols and/or Bode plots
* Compensator design via classical loop-shaping
* Case studies

Implement the skills and knowledge acquired during the module in the design and construction of a complete product.

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**Module Title:** Electrical Energy Systems and Control B

**Module Code:** 34558

**Semester:** 2

**Credits:** 10

**Level:** LI

**Module Description:**

Control Engineering

* Introduction to Control Engineering
* Control fundamentals:
  + Modelling of simple mechanical and electric systems
  + Analysis of systems
  + Steady state error analysis, stability (Simplified Nyquist), stability margins.

Control Design

* Design based-upon Nichols and/or Bode plots
* Compensator design via classical loop-shaping
* Case studies

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**Module Title:** Power Electronic and Power Systems

**Module Code:** 30037

**Semester:** 1

**Credits:** 20

**Level:** LH

**Module Description:** Students will build upon their knowledge of single phase and three phase systems, transformers, switching devices and transmission lines, to develop an understanding of the issues behind power conversion systems, power transmission & distribution systems, perform power flow studies using analytical methods and computational tools, analyse reactive power and voltage control of power transmission and distribution systems as well as fault current calculations.

The course explains the method to evaluate performance and characteristics of single-phase and three-phase rectifiers and inverters. The control of AC rotating machines and power quality issues are presented as examples of application.

Lectures on theory and operating principles will be backed up by tutorials on practical case studies and laboratory exercises on computer simulations and experimental tests.

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**Module Title:** Advanced Communications Systems

**Module Code:** 30066

**Semester:** 1

**Credits:** 20

**Level:** LH

**Module Description:**

1. RF & Microwave Communicaton link components.
   1. An introduction to Noise temperature, noise factor and sources of noise.
   2. Discussion of microwave links based on Link budget.
2. Basic theory of antennas, their properties and behaviour.
   1. Microstrip antennas. Mobile phone antennas. Array antennas for smart/adaptive communications and radar.
3. Plane wave propagation and polarisation.
   1. Interaction of plane waves with dielectric and metallic boundaries.
4. Transmission Lines as an extension to normal wire conductors.
   1. Reasons for using transmission line techniques.
   2. Coaxial lines, microstrip lines, and their use in microwave circuits.
   3. Reflections, VSWR, reflection coefficient and matching.
5. Microwave measurement systems and associated errors – demonstration.
6. Introduction to Microwave CAD package for visualisation and self study.
7. Introduction to Radio System Simulation for visualisation and self study
8. Base-band signals and line codes
   1. Line codes including polar, bipolar and Manchester
   2. ISI and pulse shaping technique
   3. Matched filtering
9. Digital modulation
   1. Binary, Quadrature and M-ary Phase shift Keying
   2. Frequency shift Keying, including MSK
   3. M-ary Quadrature Amplitude Modulation
   4. Spread-Spectrum modulation
   5. Modulators and Demodulators
10. Multiple access technique
    1. Introduction
    2. Frequency division
    3. Time division
    4. Code Division
    5. Space division
11. Wireless channels
    1. Introduction
    2. Flat fading channel
    3. Frequency selective channel

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**Module Title:** Electronic Engineering

**Module Code:** 30067

**Semester:** 1

**Credits:** 20

**Level:** LH

**Module Description:** This module extends and deepens students understanding of analogue and digital electronics at level H. It is divided into two sections:

**Analogue electronics**

Power amplifier circuits are introduced. Class A, B and AB amplifiers are studied in detail along with the related issues of efficiency, power dissipation and heat sinking requirements. High frequency performance of transistors is studied. The resulting effects on the common-emitter amplifier and measures to counter them are explored. Sources of noise in electronic circuits are introduced. Concepts of noise figure, noise temperature and the design of low-noise amplifiers are studied. The design of active RC filters is introduced.

**Computer Hardware and Digital Design**

Students deepen their knowledge of design methods of digital systems and are introduced to Hardware Description Languages and automatic synthesis. Implementation styles (e.g. ASIC, FPGA) are introduced. The principal functional units of a modern computer system are designed. The principles of digital systems testing.

**Detailed Syllabus:**

**Computer Hardware and Digital Design**

1. DESIGN FLOWS
   1. Frontend and backend tools
   2. Logic synthesis and physical synthesis
   3. Implementation technologies: ASIC, FPGA, CPLD, embedded software
   4. Role of Hardware Description Languages
   5. Types of description: structural, netlist, behavioural, register transfer, algorithmic VHDL
   6. Concurrent and sequential execution
   7. Events and the event queue processes
   8. Types and type conversion
   9. Testbenches
   10. Register transfer level coding
2. COMPUTER SYSTEMS
   1. Computer organisation
   2. Memory maps
   3. Bus cycles
   4. Memory types: SRAM, DRAM, ROM, EPROM.
   5. Busses and bridges: the PC motherboard and its chipset
   6. Memory hierarchies: cache systems
3. DESIGN OF HIGH PERFORMANCE DIGITAL SYSTEMS
   1. When is hardware better than software?
   2. ASICs and FPGAs.
   3. Pipelining.
   4. Latency and throughput.
   5. Performance calculations for pipelined systems
4. MICROPROCESSOR HARDWARE
   1. RISC and CISC.
   2. Pipelined execution.
   3. Control and Data hazards.
   4. Pipeline stalls and bubbles, and their impact on throughput
   5. Resolution of control and data hazards: compiler methods; hardware methods
5. ADVANCED MICROPROCESSOR SYSTEMS
   1. Out of order execution
   2. Speculative execution and branch prediction
   3. Superscalar and superpipelined processors
6. TEST AND TESTABILITY
   1. Fault models
   2. Path sensitization methods
   3. Boolean differences
   4. Scan path methods
   5. Boundary scan
   6. Built-in self-test

**Analogue Electronics**

1. POWER AMPLIFIER DESIGN
   1. Operating modes
   2. Output stage selection
   3. Biasing
   4. Power dissipation, thermal effects and protection.
2. LOW NOISE AMPLIFIER DESIGN
   1. Sources of noise
   2. Equivalent noise generators
   3. Noise figures.
   4. Low noise design
3. RF AMPLIFIER DESIGN
   1. Cut-off frequency
   2. Gain bandwidth product
   3. Hybrid p equivalent circuit
   4. Miller Effect, the Cascode stage
4. RC ACTIVE FILTER DESIGN
   1. Synthesis by sections
   2. Dynamic range
   3. Cascade sequence and pole-zero pairing
   4. Circuits for second order sections
   5. Operational simulation
   6. Component simulation

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**Module Title:** Mechatronic Design

**Module Code:** 32798

**Semester:** 1

**Credits:** 20

**Level:** LH

**Module Description:** In this module students will learn how to specify, design and build mechatronic and robotic systems. The topics will include:

* Overview of robotic and mechatronic systems and their applications to a range of industries. Examples may include remotely operated vehicles, automotive engine management systems, autonomous robotics, ABS systems, elevators and hoists.
* Configurations of mechatronic systems; robot end effectors, sensors, safety, control units; co-ordinate systems and kinematic transformations; joints and links; inverse kinematics.
* Actuators: dynamics of drive systems, stepper motors, PM and brushless DC motors, speed and position control.
* The physical principles particular sensor types and their dynamic range and sensitivity. These might include position and velocity sensing devices, pressure sensors temperature sensors etc.

In laboratory exercises, students will be introduced to robot kinematics, sensors and actuators.

In the guided independent study time, the students are expected to review the material delivered in lectures and prepare for both the laboratory sessions and the tutorials.

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**Module Title:** The Internet of Things

**Module Code:** 30065

**Semester:** 2

**Credits:** 20

**Level:** LH

**Module Description:**

PART ONE: The Internet of Things (10 credits)

1. Introduction: example applications {home, sports, health, cities, retail, transport};
2. IoT ecosystems;
3. Business, Technology and Economic Drivers for IoT: anticipated benefits,
4. Changes to business processes and business models
5. Legal challenges, privacy and security issues
6. Societal implications, PersausivePersuasive technology and behavioural change, the quantified self
7. IoT Services: brokering, big data analytics, dependability, maintainability
8. IoT Sensing and Display modules; human interaction with IoT
9. Data analysis and decision making
10. Design methods and approaches

PART TWO: Computer Networks (10 credits)

1. Basic Internet comms: layers (OSI model etc.), and protocols (TCP, UDP etc.)
2. Addressing and routing: MAC, IP, DNS, DHCP, NAT etc.
3. Comms for the IoT: wireless standards, specialised protocols (e.g. zigbee, RFID / NFC, GSM, LTE, etc.)
4. Managing data loss (CRC, estimating packet loss, quality models, etc.)
5. Models for data access on the web (WSDL, SOAP, REST, etc.)
6. Data models for sensor networks (SensorML etc.)
7. Architectures for the management of sensor networks / exchange of sensor data (configuration, address assignment, contribution of data etc.)
8. Network security models

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**Module Title:** Telerobotics, Telepresence and Augmented Reality

**Module Code:** 32802

**Semester:** 2

**Credits:** 20

**Level:** LH

**Module Description:** In this module students will learn how to specify, design and build novel human-system interfaces, based on VR, AR and MR (Mixed Reality) technologies for controlling remotely operated land, air and underwater vehicles (ROVs).

Students will learn about the history and principles of telerobotics, telepresence and the parallel domain of VR, AR and MR and how they are, and can be applied in engineering applications.

The selection of appropriate commercial off-the-shelf toolkits for designing VR/AR/MR interfaces for ROVs will be discussed, as well as factors affecting their integration with the vehicle to provide real-time control and data presentation to the human user. Methods for specifying the interfaces will be considered, as will techniques for evaluating the quality of system performance.

The students are expected to undertake the design, construction and testing of any prototypes for the project during the guided independent study time, so that they will be ready to present it and demonstrate it on the demonstration day.

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**Module Title:** Introductory Module for Computer Engineering

**Module Code:** 30057

**Semester:** 1

**Credits:** 20

**Level:** LM

**Module Description:** There are two parts to this module. In Part 1 an introduction for two M.Sc. programmes (MSc in Electronic and Computer Engineering; MSc in Communications Engineering) is given. Part 2 focuses on aspects relevant to some other modules in the MSc Electronic & Computer Engineering programme and is also expected to be useful for the MSc project.

Part 1:

* Case studies in Professional Engineering covering:
  + professional and ethical conduct in engineering
  + the commercial and social context
  + management and business practices
  + sustainable development
  + regulatory requirements
  + health & safety, environmental and commercial risk
* Introduction to signal processing
* Fourier transform
* Basic probability concepts
* Introduction to data analysis
* Programming in Matlab
* Presentation and report writing skills

Part 2:

* Mathematical techniques: Laplace Transform, Z Transform
* Linear Algebra

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**Module Title:** Introductory Module for Electrical Power

**Module Code:** 33128

**Semester:** 1

**Credits:** 20

**Level:** LM

**Module Description:** There are two parts to this module. In Part 1 an introduction for three M.Sc. programmes (MSc in Electronic and Computer Engineering; MSc in Communications Engineering, MSc in Electrical Power Systems) is given. Part 2 focuses on aspects relevant to some other modules in the MSc Electrical Power Systems Engineering programme and also expected to be useful for the MSc project.

Part 1:

* Case studies in Professional Engineering covering:
  + Professional and ethical conduct in engineering;
  + The commercial and social context;
  + Management and business practices;
  + Sustainable development;
  + Regulatory requirements;
  + Health & safety, environmental and commercial risk;
* Introduction to signal processing;
* Integral transforms;
* Basic probability concepts;
* Introduction to data analysis;
* Programming in Matlab;
* Presentation and report writing skills.

Part 2:

The module will introduce basic concepts and programming skills using MATLAB; develop skills in modeling generic differential equations using SIMULINK; develop skills in modeling power electronic dynamic systems; develop skills in modelling electrical machine dynamic systems and develop advanced skills in modelling complex electrical power systems and dynamics using S-function and user-defined function.

The module will introduce the methods for control system design for linear and time-invariant dynamics, and this will include classical methods for single input – single output (SISO) systems; both analogue and digital controller designs based on frequency-response, prototype closed loop dynamics and pole-placement techniques; state-space based methods in the design of state feedback and state-feedback-observer controllers for multivariable systems based on pole placement in MATLAB.

The module will introduce basic concepts of smart grids, smart grid architecture designs. This module will then introduce major smart grid technologies. This will be followed by the performance analysis tools for smart grids. Finally the module will provide the understanding of interoperability, standards and security needs for smart grids developments.

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**Module Title:** Software and Systems

**Module Code:** 30056

**Semester:** 1

**Credits:** 20

**Level:** LM

**Module Description:** This module consists of three broad categories: Programming, Design and the Development lifecycle.

In programming, an introduction to procedural and object oriented programing are given e.g. operators, loops, data types, functions, classes, files and GUI applications etc.

In design, the basic concepts associated with functional decomposition and abstraction are given. This includes the use of standard modelling languages e.g. UML and SysML.

In lifecycle, the different stages of the software and systems engineering lifecycle are introduced and their impact on programming and design highlighted, e.g. requirements analysis, quality, testing and maintenance.

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**Module Title:** Advanced Digital Design

**Module Code:** 30054

**Semester:** 2

**Credits:** 20

**Level:** LM

**Module Description:**

1. To briefly revise core skills in digital design such as Boolean algebra, K-maps, logic gates and flip-flops.
2. To introduces finite state machine topologies and design processes. This includes both synchronous and asynchronous machines.
3. To give students practical experience of designing synchronous and asynchronous finite state machine on programmable devices.
4. To introduce FPGA’s: architectures, targeting for synthesis.
5. To introduce VHDL: basic concepts of HDLs; design entities; sequential and concurrent execution; signals and variables; process statements; guarded blocks; data types in VHDL.
6. To reinforce the student learning experience using hands-on implementations of digital circuits developed by the students.

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**Module Title:** Data Mining and Machine Learning

**Module Code:** 30058

**Semester:** 1

**Credits:** 20

**Level:** LM

**Module Description:** Data Mining and Machine Learning is concerned with computational techniques for data analysis, to extract relevant information or discover underlying structure. The course consists of three parts. Part 1 concentrates on text and presents the principles which underpin current text search engines. Part 2 is concerned with generic techniques for analysing and discovering the underlying structure of general data sets. Part 3 will focus on application of hidden Markov models to automatic speech recognition.

TEXT-BASED INFORMATION RETRIEVAL:

* Zipf's Law, Query-document similarity, Term-Frequency, Inverse Document Frequency, Topic spotting, Latent Semantic Analysis.
* Laboratory session 1: Implementation of a simple Search Engine using provided C implementations of the techniques covered.

DATA ANALYSIS AND MACHINE LEARNING:

* Statistical modelling and probability estimation; Maximum Likelihood estimation for Gaussian PDFs and Gaussian Mixture PDFs (the E-M algorithm); Principal Component Analysis, Clustering; Neural Networks; Hidden Markov models (HMMs).
* Laboratory Session 2: Application of agglomerative and k-means clustering.

APPLICATIONS – SPEECH/AUDIO PATTERN PROCESSING:

* Spectral analysis of speech/audio data; Basics of human speech production and perception; Introductory phonetics; Automatic speech recognition (ASR) – acoustic modelling, language modelling, adaptation.
* Laboratory Session 3: Analysis of speech/audio data; Development of an ASR system using provided software tools.

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**Module Title:** Small Embedded Systems

**Module Code:** 21479

**Semester:** 2

**Credits:** 20

**Level:** LM

**Module Description:** The aims of this course are to:

* Introduce the theory and practical skills relating to embedded systems design construction for industrial applications.
* Review basic concepts in digital and analogue circuit design and C programming.
* Introduce students to the key design criteria and programming design tools useful to embedded systems design.
* Make students aware of an array of communications buses and peripheral devices that can be used as part of an embedded system.

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**Module Title:** Computer and Communications Networks

**Module Code:** 21483

**Semester:** 2

**Credits:** 20

**Level:** LM

**Module Description:** The aims of this course are to:

* Review the basic notions of layered architectures in data networks
* Review the basics of queuing theory and its use in modelling networks
* Introduce two to three advanced networking topics of current interest
* Make students aware of analysis techniques used in the study of the performance of (aspects of) networks
* Introduce students to network programming and/or simulation.

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**Module Title:** Sensing and Control for Autonomous Systems

**Module Code:** 30055

**Semester:** 2

**Credits:** 20

**Level:** LM

**Module Description:** This module will focus on the techniques and methods required for the development of autonomous systems. The module will consider:

* How sensors are used to sense the world;
* Modern control methods that can be used to mathematically model or estimate the function of real systems in some way;
* A range of autonomous decision making approaches, including optimisation to ensure desired outcomes;
* Actuation and overall system design, including: safety integrity levels; common model failures; fault detection, diagnosis and prognosis; and fault tolerance.

The module will draw on mathematical approaches, but will be primarily practically focussed. Real systems will be considered throughout the module, with a range of systems (primarily, but not limited to, electro-mechanical sub-systems) being used as examples through the module to support the theoretical approaches and to ensure relevance.

Initially, the module will consider the range of autonomous systems that are currently in use (e.g. automatically operated trains, robotic control), and are likely to come into use in the future (e.g. driverless cars, fault tolerant systems). Students will use these examples to consider the uses for autonomous systems, and common building blocks (sensing, control strategies, automation and actuation), as well as overall system design aspects.

The module will then be considered in four phases (Phase 1: sensing, Phase 2: control strategies, Phase 3: automation, Phase 4: actuation and systems).

* Introduction: Use of autonomous systems (2 hours of lectures)
* Phase 1: Sensing (2 hours of lectures), considering: (i) the range of sensors that may be used; (ii) methods for data acquisition, and issues associated with different techniques (e.g. Nyquist, noise, etc.); (iii) approaches to acquire difficult to measure parameters.
* Phase 2: Control Strategies (12 hours of lectures), considering: (i) modelling dynamic systems using transfer functions, with a particular focus on electro-mechanical systems; (ii) model based control; (iii) stability of control systems; (iv) multiple-input-multiple-output systems; (v) state space analysis; (vi) controllability and state observability; (vii) feedback control methods using observability and parameter estimation; (viii) fuzzy control; (viii) digital control.
* Phase 3: Automation (10 hours of lectures), considering: (i) rule based and optimisation approaches; (ii) Brute Force and enumeration; (iii) linear programming; (iv) genetic algorithms; (v) graph based approaches; (vi) dynamic programming; (vii) simulated annealing; (viii) ant colony; (ix) Tabu search; (x) other artificial intelligence approaches.
* Phase 4: Actuation and systems (4 hours), considering: (i) timings; (ii) processing requirements; (iii) hardware development; (iv) system dependability (reliability, availability and safety); (v) fault detection, diagnosis and prognosis; (vi) fault tolerance; (vii) overall system design.

The module will be supported by two distinct laboratory exercises (that will use Matlab/Simulink to support the theory covered in the lectures (24 hours across the two exercises). The first laboratory will focus on control strategies (Phase 2), while the second laboratory will consider automation and overall system design (Phases 3 and 4).

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**Module Title:** HVDC & FACTS

**Module Code:** 26430

**Semester:** 2

**Credits:** 20

**Level:** LM

**Module Description:** The deregulation of the electricity market together with increasing constraints resulting from social opposition to the installation of new facilities brings great pressure to the operators of transmission and distribution systems. Large scale integration of renewable energy into power supply brings further pressure on how to operate and control future power networks.

These new trends require the need for flexibility, power quality and increased availability of electricity transmission and distribution systems by using new devices which can be implemented with limited investments, short delivery times and short planning and decision making horizons.

FACTS (Flexible AC Transmission Systems) is a terminology to describe a whole family of concepts and devices for improved use and flexibility of electrical power systems. HVDC is used for long distance power delivery, interconnection of asynchronous AC systems and integration of large scale renewable energy systems. There are two types of HVDC systems such as LCC HVDC and VSC HVDC.

The course covers the basic concepts and operating principles of HVDC and FACTS. The new developments in multi-terminal HVDC Grid will be discussed.

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**Module Title:** Power System Economics

**Module Code:** 26641

**Semester:** 2

**Credits:** 20

**Level:** LM

**Module Description:** This module takes a complementary approach, and builds on existing knowledge about power system engineering, power market, energy economics and policy, and consumer behaviour, to help engineering students develop an interdisciplinary and theoretically informed understanding of power system economics. It will examine a range of contemporary policy, regulation and economics issues (competition, marketing restructuring, market power, whole sale and retailing, pricing mechanism, demand response and demand-side management) involved in the power and energy market.

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**Module Title:** Renewable Energy Systems Integration

**Module Code:** 27528

**Semester:** 2

**Credits:** 20

**Level:** LM

**Module Description:** The module covers energy storage, distributed generation including Wind, PV, and CHP, micro grid planning and operation, integration of distributed generation into power distribution networks, and economical aspects of distributed generation and micro grids.

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**Module Title:** Power System Stability Control and Protection

**Module Code:** 30064

**Semester:** 1

**Credits:** 20

**Level:** LM

**Module Description:** This module deals with power system stability, control and protection problems and associated advanced analysis and design techniques. The module covers synchronous machine theory and dynamic modelling; synchronous machine parameters for dynamic models; synchronous machine dynamic representation in stability studies; small signal stability and control of a single-machine infinite bus; method for the analysis of small signal stability and control of multi-machine systems; control concepts such as Excitation Control and Power System Stabilizer (PSS); basic concepts and protection principles of power systems such as over current, distance, busbar, transformer and generator protections; analytical calculations, settings and coordination for power system protection; and advanced protection concepts and methods such as Intelligent Electronic Devices (IED), Smart Substation, IEC61850, System Integrity Protection Strategies.

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**Module Title:** Power Systems Operations and Control

**Module Code:** 26432

**Semester:** 1

**Credits:** 20

**Level:** LM

**Module Description:** This module deals with modern power system operational and control problems and associated advanced solution techniques. State estimation, contingency analysis, load-frequency control and automatic generation control. Load flow analysis and stability modelling and control.

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**Module Title:** Electromagnetics, Antennas and Propagation

**Module Code:** 24083

**Semester:** 1

**Credits:** 20

**Level:** LM

**Module Description:** The aims of this course are to:

* Review the mathematical techniques on which electromagnetics rely
* Make students aware of analytical methods
* Make students aware of computer aided design
* Give insights on the operating principles of a number of electromagnetic components
* Understand the basic principles of antenna operation, analysis & design
* Understand the physics of radiowave propagation at a number of frequency bands and environments

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**Module Title:** Satellite, Mobile and Optical Communications

**Module Code:** 24097

**Semester:** 2

**Credits:** 20

**Level:** LM

**Module Description:** The aims of this course are to introduce and overview the wide range of current personal and mobile, satellite and optical communication systems; to describe the propagation environment involved in such systems and to explain methods of characterisation; to explain typical modulation, coding and multiplexing methods; to describe the system and network aspects of typical mobile systems; to introduce optical fibres, laser diodes and Photo-detectors; to discuss in detail: optical transmitters; optical receivers; and optical fibre communication systems in particular coherent fibre communications and wavelength division multiplexing systems.

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**Module Title:** Digital Communications and Signal Processing

**Module Code:** 30059

**Semester:** 1

**Credits:** 20

**Level:** LM

**Module Description:** In the first part of module, students should become familiar with analysis and synthesis of digital communication systems by means of the statistical theory that is the core of any information exchange and specifically digital data. They should gain an understanding of the fundamental principles of communication that will be used in all communication related courses. The second part of the module covers the principles of optimal signal detection and processing to minimize the Bit Error Rates (BER). It will be considered dependence of BER and Signal Noise Ratio (SNR) for different kind of modulations used in modern systems. And finally the third part will be an introduction in the technique of digital signal processing by means of digital filters, Fourier Transform and signal processing in frequency domain. All mentioned above is the subject of assignment where the students will Modell a communication systems using Matlab software.

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**Module Title:** Radar and Satellite Navigation

**Module Code:** 30060

**Semester:** 2

**Credits:** 20

**Level:** LM

**Module Description:** In the first part of the module, students should become familiar with the principles of RF passive and active radar operation, their main applications and major signal processing techniques. They will learn the principles of radar system design and how sensors are parameterised. In the second part of the module, students will be introduced to the principles of satellite navigation and learn the signal processing techniques that facilitate it. Through coursework students will learn how to apply theoretical concepts to practical system design.

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**Module Title:** RF and Microwave Engineering

**Module Code:** 30061

**Semester:** 2

**Credits:** 20

**Level:** LM

**Module Description:** The module covers the principles of RF and microwave engineering that underpin the design of analogue front end elements of communication systems. Computer simulation of passive and linear active microwave circuits is also introduced through laboratory sessions.

The basic building blocks of RF and microwave systems, including filters, couplers, amplifiers, mixers and oscillators, will be introduced. Typical technologies, circuit configurations and electromagnetic structures used in realising these building blocks will be covered. Methods of analysing passive and active circuits will be developed.. CAD techniques for RF and microwave circuits will be introduced and the capabilities and characteristics of field solvers and circuit simulators will be studied and compared. Linear, non-linear and noisy circuits will be analysed using circuit simulation CAD. CAD based tuners and optimisers will be introduced and their advantages and disadvantages will be discussed.

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# Mechanical Engineering

**Module Title:** Mechanics 2

**Module Code:** 23777

**Semester:** 1

**Credits:** 20

**Level:** LI

**Module Description:** The aim of the module is to is to enhance students' knowledge and understanding of the mathematics and scientific principles related to mechanics and materials, and to develop their ability to apply this knowledge in a number of topics.

SYLLABUS

Static analysis of stress in solid mechanics, including use of Mohr's Circle, maximum shear stress, strain energy and von Mises failure criterion, energy methods, Castigliano's Theorem for beam deflection, analysis of thin walled vessels. Vector analysis of the dynamics (both kinematics and kinetics) of two-dimensional rigid body systems with applications to simple linked systems of rods, gears and wheels.

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**Module Title:** Mechanical Design A

**Module Code:** 23808

**Semester:** 1

**Credits:** 20

**Level:** LI

**Module Description:** The aim of the module is to enhance students' knowledge and understanding of the mathematics and scientific principles related to mechanics, materials, manufacturing and design processes, and to develop their ability to apply this knowledge in a number of topics. SYLLABUS:

* COMPUTER AIDED DESIGN AND MATERIALS SELECTION: Use of Solidworks, Use of CES Edupack
* DESIGN: Product Design Specification, Engineering drawings to BS8888
* MATERIALS: The concept of systematic material, shape and process selections that takes into account formal constraints and objectives derived from the products’ functional/technical specifications is introduced to students based on CES EduPack functionality. Also, the formal approaches for managing multiple constraints and objectives in engineering design of products are introduced to students and case studies are provided. The complex relations between materials, product functionality, component shapes and the processes for their cost-effective manufacture are elaborated and examples are given.
* SUSTAINABILITY: The scientific principle of using life-cycle product data to inform the product design and material and process selections are elaborated. Systematic eco-design approaches for selecting engineering designs and re-designing products are introduced that take into account eco-fingerprints of design decisions and allow “what-if” studies to be carried out employing the CES EduPack build-in capabilities.
* IN-SERVICE FAILURE: The concept of finite and infinite life of machine components. The stress-strain curve and its relationship to fatigue. Understanding different fatigue regimes. Fatigue analysis using Soderburg and Goodman diagrams. Stress raisers and fatigue initiation. Identifying the features of a fatigue fracture. Effect of surface and other processes on fatigue, peening/blasting, welding, geometry and size.
* MACHINE ELEMENT THEORY: Theory of gears - nomenclature, conjugate sliding motion, sliding velocities, contact ratios, numbers of teeth, geometric relationships. Types of gear, Gear trains. Shafts - Sizing and failure analysis, DET and MSST theories, design methods, stress analysis, shear force, bending moment and deflection analysis.
* MECHANICAL DESIGN: Procedures for the practice of mechanical design, concepts of axial, radial, circumferential location, basic bearing design, lubrication, static and dynamic seals. Selection of component bought out from specialist suppliers, design and validation of components to be manufactured in-house, selection of materials, manufacturing methods or systems concepts that are related to more than component. Use of appropriate software in the design process.
* MATERIALS PROCESSING: The students are introduced to the following manufacturing processes: Machining - Conventional machining, turning, drilling, milling, grinding, EDM. Metal forming - bulk forming, forging, extrusion, sheet metal forming - rolling, pressing. Casting - sand, HP die, investment, gravity die, low pressure die. Joining - fusion welding, resistance welding, adhesive bonding, rivets. Special Processes - prototyping, laser deposition, CVD - surface coatings, plasma spraying.

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**Module Title:** Engineering Mathematics 2

**Module Code:** 29650

**Semester:** 1

**Credits:** 20

**Level:** LI

**Module Description:** In this module, mathematical techniques required by the second year Electronic and Electrical Engineering, Mechanical Engineering and Civil Engineering programmes are covered.

* Integral transforms
* Fourier series
* Fourier transforms
* Laplace transforms
* Multivariable calculus
* Partial differentiation and the gradient
* Line integrals
* Surface and volume integrals
* Divergence and Curl
* Linear Algebra
* Vector representation of documents and text retrieval
* Linear dependence, orthonormal bases, the Gram-Schmidt process
* Linear transformations and matrices, vector subspaces, subspace projections
* Eigenvector decomposition, covariance and Principal Components Analysis (PCA)
* Metric spaces and clustering
* The Discrete Fourier Transform
* Probablility and statistics
* Probability
* Probability distributions and random variables
* Descriptive statistics
* Hypothesis testing
* Handling experimental data and experimental uncertainty
* Statistical decision making
* Markov processes

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**Module Title:** Thermodynamics and Fluids

**Module Code:** 23809

**Semester:** 2

**Credits:** 20

**Level:** LI

**Module Description:** The aim of the module is to:

* introduce fluid mechanics of real incompressible internal and external flows (following on from frictionless flows and basic hydraulics) including the basics of boundary layer concept, friction in flow, drag, lubrication, flow separation, form drag and lift, basic mechanics of flying and sailing. This is followed by an introduction to 2 and 3 dimensional conservation equations including Navier-Stokes;
* introduce the various ideal thermodynamic cycles that form the basis for power generation, heat pumping and refrigeration. It will also emphasise the difference between the actual and ideal cycles and methods of enhancing the performance of actual cycles.

The module will also introduce fuels, including biofuels and the basic chemistry of combustion and IC Engines performance.

SYLLABUS: Semester 1 - Heat Engines and Heat Pumps:

1. Second Law of Thermodynamics, Concept of heat engines and heat pumps
2. Ideal single phase heat engine cycles, Otto, Diesel, Gas Turbines Cycle (Brayton)
3. Two Phase fluid properties, Ideal Two phase heat engine cycle, Simple Rankine Cycle
4. Complex steam Power plant cycles
5. Vapor Compression refrigeration and heat pump cycles

Semester 1 - Combustion, Engines and Emissions:

1. Mixtures
2. Combustion - stoichiometry, thermal effects, flame temperature
3. ICE Engines - basic performance calculations
4. Fuel and biofuels

Semester 2:

1. Revision of friction in internal flows
2. Introduction to Boundary Layer
3. Friction in external flows,
4. Drag on flat plate
5. Lubrication.
6. Separation, Form drag, lift, induced drag, polar diagrams
7. Flying and sailing
8. Conservation Eqns, introduction to Navier-Stokes
9. Introduction to "cold" CFD methodology

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**Module Title:** Mechatronics and Control Engineering

**Module Code:** 31737

**Semester:** 2

**Credits:** 20

**Level:** LI

**Module Description:** The aim of the module is to:

* enable students to understand and use sensors, microprocessors and actuators in engineering designs and applications.
* further develop students’ knowledge in advanced statics, dynamic system control and vibration, and to prepare students to solve relevant engineering problems in their future careers

MECHATRONICS SYLLABUS

Advanced boolean algebra, number systems, bus communications, ROM, RAM, memory map, microcomputer architecture, AD and DA converters, programmable controllers, introduction to stepper motor, sensors, switches, and mechatronic system design.

CONTROL ENGINEERING SYLLABUS

1. Modelling of simple mechanical and electric systems;
2. Building up transfer functions of dynamic systems;
3. Block diagram analysis;
4. Introduction to open and closed loop systems;
5. Dynamic responses of first order and second order systems;
6. Input signals, system stability and dynamic errors;
7. Controller design and system improvement.

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**Module Title:** CFD and FEA

**Module Code:** 22961

**Semester:** 1

**Credits:** 20

**Level:** LH

**Module Description:** The aim of the module is to introduce the basic theories of finite element analysis and computational fluid dynamics techniques.

SYLLABUS

General theories of FEM:

1. 1D and 2D FE theories
2. Differences between Lagrangian and Eulerian specifications of motion
3. Mesh generation and convergence
4. Data Analysis & Post Processing
5. Validation & Verification

Finite element analysis:

1. Formulation of stiffness matrix and system equations for 1D pin-jointed bar element
2. Assembly of global stiffness matrix
3. Formulation of stiffness matrix and system equations for 2D plane stress/strain elements
4. Commercial software (ABAQUS)

Computational Fluid Dynamics:

1. Basic concepts
2. Governing equations of fluid dynamics - Navier-Stokes Equations
3. Compressible and incompressible flows - Applications
4. Turbulence and its modelling
5. Applications of CFD
6. Commercial software

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**Module Title:** Mechanical Design B

**Module Code:** 22964

**Semester:** 1

**Credits:** 20

**Level:** LH

**Module Description:** The aim of the module is to enhance students’ knowledge and understanding of the mathematics and scientific assembly, systems integration, principles related to mechanics, materials, manufacturing and design processes, and to develop their ability to apply this knowledge to real-life industrial designs.

SYLLABUS

* COMPUTER AIDED DESIGN: Use of Solidworks
* DESIGN: Product Design Specification, Engineering drawings to BS8888
* MACHINE ELEMENT THEORY: Theory of flexible machine elements, nomenclature, kinematics and kinetics, geometric relationships. Types of flexible machine elements. Power translation screws, Square, V and buttress threads, force and stress analysis, and friction analysis. Cams - Types of cam, nomenclature, kinematics and kinetics, geometric relationships, cam/follower relationships.
* MECHANICAL DESIGN: Concepts of axial, radial, circumferential location, bearing (rolling & journal) elastohydrodynamic lubrication, static and dynamic seals. Selection of component bought out from specialist suppliers, design and validation of components to be manufactured in-house, selection of materials, manufacturing methods or systems concepts that are related to more than component. Use of appropriate software in the design process.
* DESIGN FOR SYSTEMS INTEGRATION: Concepts and principles of design for assembly of major sub-systems, design for systems integration including mechanical systems, actuators, sensors, etc.
* DESIGN FOR COMPONENT ASSEMBLY: Concepts and principles of design for assembly (DFA) and design for automated assembly (DFAA), design guidelines, Lucas DFA method including design efficiency analysis, feeding and fitting ratios. Hitachi DFA method including the assembly ability evaluation score ratio (E) and assembly cost ratio (K), and Boothroyd-Dewhurst method including assembly time and cost, and minimum number of parts. Lucas DFA Method on Manufacturing Cost Analysis.

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**Module Title:** Sustainable Energy and the Environment

**Module Code:** 22387

**Semester:** 1

**Credits:** 10

**Level:** LH

**Module Description:** The aim of the module is to introduce efficient and sustainable energy systems, including CHP, combined cycles of steam and gas turbines, fuel cells and optimization of heat recovery by pinch technology. It also introduces renewable energy systems including wind energy, nuclear energy and solar energy.

Syllabus

* Efficient and Sustainable Energy Systems including:
  + Combined Steam and Gas Power Cycles,
  + Combined Heat and Power
  + Combined Cooling, Heating and Power (Trigeneration)
  + Heat Exchangers and Pinch Technology for optimisation of energy recovery
  + Energy Scenario and Fuel Cells
* Renewable Energy Systems including:
  + Wind Energy and Slip Stream Theory for Wind Turbines
  + Nuclear Energy
  + Solar Energy, Radiation Heat Transfer and Greenhouse effect.

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**Module Title:** Turbomachinery and Compressible Flows

**Module Code:** 24360

**Semester:** 1

**Credits:** 10

**Level:** LH

**Module Description:** The aim of the module is to provide the opportunity for the students to apply their CAE skills on a project that requires the integration of these skills.

SYLLABUS

Elements of engine turbocharging; Thermodynamics of turbo- and supercharging; Basic compressible flow in engines (valves, manifolds); Elements of non-ideal compressible flows: shock, heat transfer, friction; Blading in Pumps and Turbines, Momentum Transfer; Turbocharging systems - principles of matching.

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**Module Title:** Engineering Mathematics 3

**Module Code:** 23779

**Semester:** 2

**Credits:** 20

**Level:** LH

**Module Description:** The aim of the module is to enhance the students’ mathematical knowledge and confidence in preparation for the demanding applications of the final stage modules, and a possible research career involving engineering science. They will develop an understanding of the numerical techniques used within modern Finite Element Analysis computer packages and develop an understanding of the mathematical basis of many of the advanced systems of equations governing engineering problems.

SYLLABUS

1. Vector differential calculus:
   1. review of vectors and geometry;
   2. curvilinear coordinates;
   3. review of grad, div, curl;
   4. calculus for parametrised fields;
   5. applications: PDE of physics and engineering.
2. Vector integral calculus:
   1. line, surface, volume integrals
   2. Stokes’ theorem and Gauss’ divergence theorem;
   3. integro-differential identities;
   4. applications: length, area, volume, mass, conservation laws.
3. Numerical methods:
   1. Nonlinear iterations with application to root-finding methods:
   2. Bisection method
   3. fixed point iteration method;
   4. secant and Newton's method;
   5. interpolation by polynomials:
   6. Lagrange and Hermite interpolation;
   7. piecewise polynomial interpolation;
   8. numerical integration:
   9. Newton-Cotes rules;
   10. Gauss quadratures;
   11. product rules;
   12. numerical methods for initial value problems
   13. Euler methods;
   14. explicit Runge-Kutta methods.

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**Module Title:** Powertrain and Vehicle Engineering

**Module Code:** 23806

**Semester:** 2

**Credits:** 20

**Level:** LH

**Module Description:** The aim of the module is to introduce the processes and cycles involved in the design and development of the modern automotive vehicle and how they are facilitated by the organisation of the industry. The student will acquire a basic understanding of the dynamics of vehicle systems affecting acceleration, braking and vehicle ride, leading to the development and application of simple mathematical analysis and simulation techniques, and to the design and analysis of vehicle systems and components. The student will also acquire a basic understanding of the energy supply, design and analysis of vehicle powertrain systems, with emphasis on the practical design of components and whole systems. The module will also introduce advanced vehicle technology including hybrid and electrified vehicles. The module will also introduce advanced vehicle technology including hybrid and electrified vehicles.

SYLLABUS

The vehicle development process:

* Organisation of the motor industry: OEMs, suppliers and inter-relationships
* The vehicle design and development process
* Examples of Product Development System

Vehicle Dynamics:

* Vehicle external forces and axle loads
* Vehicle acceleration performance including traction limits
* Simulation of Vehicle acceleration performance
* Vehicle braking, adhesion limits and braking efficiency
* Noise, Vibration and Harshness in motor vehicles: Customer comfort and safety issues
* Dynamic characteristics of vehicle subsystems: tyre, suspension, body structure
* Analysis of vehicle ride: design considerations, ride modeling
* Energy supply
* Engine types and operation
* Engine design and operating parameters
* Drivetrains
* Design analysis of major engine components

Transmission systems:

* Gearboxes (manual, automatic)
* Constant velocity joints
* Final drives
* Advanced vehicle technology including hybrid and electrified vehicles

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**Module Title:** Advanced Manufacturing

**Module Code:** 33330

**Semester:** 1

**Credits:** 20

**Level:** LM

**Module Description:** The aim of the module is to expose students to the modelling of manufacturing processes and also to introduce them to laser-based manufacturing technologies. The first part will cover the generic aspects in modelling a wide range of advanced manufacturing processes while the second part will mainly focus on enhancing the students’ knowledge and understanding in the field of laser material processing and its integration into application specific manufacturing platforms/machines.

SYLLABUS

The first part of the module will cover the differences between the different numerical techniques available (FEM, FVM, FDM etc.). Other topics covered will include: the influence of geometry and meshing, the relationship between the physics of processes and process parameters and defect predictions and the influences of boundary conditions, thermo-physical and other property data. The modelling aspects of advaced manufacturing technologies that will be covered include metal removal (machining), powder metallugy (hot isostatic pressing), sheet forming (rolling, deep drawing), bulk forming (closed die forging and bi-metallic forming) and casting (investment casting).

The second part of module will provide the necessary ability to design and implement laser-based manufacturing solutions by applying theoretical, modelling and practical knowledge about the fundamentals of laser-material interactions, process monitoring, component technologies/systems of laser-based manufacturing platforms and application specific implementations of different machine configurations and beam delivery systems. The practical skills covered includes: laser-based manufacturing fundamentals (laser phenomena and principals, classification of laser sources and factors affecting laser-material interactions; process design, monitoring and modelling; classification of laser-based manufacturing processes; component technologies/systems for laser-material processing); laser-based additive manufacturing platforms (classification, manufacturing workflow, data preparation, layer-based processing of liquid polymers, discrete particles and sheets, machine design and implementation, process optimisation issues, applications); laser-based subtractive manufacturing platforms (classification, machine configurations, beam delivery systems, process design, monitoring and optimisation, CAD/CAM solutions, machining strategies, applications).

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**Module Title:** Bio-medical and Micro Engineering

**Module Code:** 33350

**Semester:** 1

**Credits:** 20

**Level:** LM

**Module Description:** The aim of the module is to give an overview of how mechanical engineering can be applied to medicine and micro engineering.

The following topics will be used to illustrate how mechanical engineers can apply their skills and knowledge in medicine:

* Physiological systems
* Biological systems & structures
* Bone & connective tissues
* Failure of connective tissues
* Biomechanics
* Computational methods
* Model validation
* Medical Device Design
* Fracture fixation
* Joint replacement
* Tribology of joints
* Pre-clinical testing.

The following topics will be used to illustrate how mechanical engineers can apply their skills and knowledge in micro engineering, particularly looking at manufacturing processes developed in the micro and nanofabrication industry:

* micro electro mechanical systems (MEMS)
* crystallography
* material deposition
* photo lithography
* advanced lithography techniques
* etching
* micro mechanics,
* microelectronics
* design of applications such as accelerometers, pressure sensors, biosensors and optomechanical chemical systems.

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**Module Title:** Advanced Vehicle Engineering

**Module Code:** 33362

**Semester:** 1

**Credits:** 20

**Level:** LM

**Module Description:** The aim of the module is to assess aspects of vehicle chassis design with particular emphasis on body structure design, giving consideration to external styling, packaging, vehicle interior design and vehicle safety.

It will provide the student with a basic understanding of the dynamics of vehicle systems affecting vehicle handling, leading to the development and application of analytical models and commercial software tools, and to the design of vehicle systems.

SYLLABUS

* Chassis design and packaging:
* Vehicle body styling and aerodynamics
* Packaging trends: common platform for different body styles
* Power unit configurations
* Ergonomics, seating and Instrument panels
* Vehicle safety systems: safety under impact,occupant protection/restraint, legislation etc.
* Body trim and fittings, electrical & electronic controls
* Packaging for weight distribution and dynamic stability

Analysis of vehicle handling:

* Vehicle handling models
* Steady state response
* Transient response to steering inputs
* Vehicle stability and design considerations
* Application of commercial tools: MATLAB, SIMULINK, CARSIM etc.

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**Module Title:** Industrial Automation and Robotics

**Module Code:** 33370

**Semester:** 1

**Credits:** 20

**Level:** LM

**Module Description:** This module considers the specific concept of design for manufacturing automation including robotic workcell design and integration, robot programming, robot workcell simulation, industrial robot selection based on capability, operational performance, task and environmental suitability and cost. In addition, the concepts of co-operative and collaborative robots will be introduced together with associated sub-systems such as end-effectors (grippers), external sensors, control strategies, parts recognition, parts transfer, and safety systems.

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**Module Title:** Research and Professional Skills

**Module Code:** 33394

**Semester:** 1

**Credits:** 20

**Level:** LM

**Module Description:** The aim of the module is to provide students with training in mechanical engineering research methods (generic as well as specific to their dissertation research) and a set of professional skills that prepare them for a professional career.

SYLLABUS

Research skills: Information search and retrieval techniques, sources and management of information, research methods, experimentation such as design of experiments (Factorial, Taguchi, Response Surface), statistical analysis (Analysis of Variance ANOVA) and use of Minitab; project management skills such project management, use of MS project, critical path method, risk analysis, Gantt chart, four box tracking charts, design skills such as computer aided design CAD and computer aided manufacturing CAM, cost analysis and life cycle analysis.

Professional skills: Technical report writing, presentations skills, plagiarism and engineering ethics, intellectual property, health and safety.

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**Module Title:** Synoptic Mechanical Engineering

**Module Code:** 23778

**Semester:** 2

**Credits:** 20

**Level:** LM

**Module Description:** The aim of the module is to encourage students to think for themselves about engineering and to consolidate what they have learned in their degree programme. The content will be presented by a series of lectures presenting case studies accompanied by a number of web-based tutorial sheets and/or additional reading materials to enable students to think about Mechanical Engineering in the broadest sense. The syllabus will contain material from the majority of modules in the first three years of the degree.

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**Module Title:** Management Information Systems and Simulation

**Module Code:** 30082

**Semester:** 2

**Credits:** 20

**Level:** LM

**Module Description:** IT trends in the business environment; building management information systems; business process re-engineering; enterprise resource planning; future trends and cloud computing.

What is simulation? Progressive model building. The dynamics of stochastic systems. Verification, validation and experimentation; simplification, and the limitations of simulation.

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**Module Title:** Systems Engineering and Systerms Thinking

**Module Code:** 30083

**Semester:** 2

**Credits:** 20

**Level:** LM

**Module Description:** Introduction to Systems; Problem Structuring Methods; Modelling Paradigms and use of spreadsheets; Soft Systems Methodology; System Dynamics; Case Study.

Systems Failure; Systems Engineering; Supplier Development Strategies; Management of Change; Need for change, project team approach, operations strategy, choice of control system including Just-in-Time and Kanban; Implementation etc.

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**Module Title:** Advanced Mechanics and Thermal Systems

**Module Code:** 33335

**Semester:** 2

**Credits:** 20

**Level:** LM

**Module Description:** The aim of this module is to provide the opportunity for the students to study advanced aspects of Mechanical Engineering. The module specifically focuses on two areas, namely: knowledge and understanding of the mathematics and scientific principles related to mechanics; as well as the understanding and knowledge of the study of advanced aspects of thermal systems phenomena.

The module will develop the students understanding of the theory of these two areas but will also provide an opportunity for students to develop their ability to apply this knowledge to engineering problems. In the thermal systems part of the module the students will be able to apply their CAE skills on an individual and a group project, creating their own engineering software, that requires the integration of knowledge and skills accumulated in the programme of study.

SYLLABUS

Advanced Mechanics

* 1. Classical mechanics: Lagrangian mechanics, constraint forces, non conservative forces
  2. Impact mechanics and stress waves: Suddenly applied loads, impact loads. The effects of high strain rates, high-velocity impact, effect on material properties, stress waves.
  3. Advanced dynamics: Kinematics and Kinetics of rigid bodies moving in 3D space, angular velocities and accelerations, general and relative motion, inertia, force and torque for rigid bodies in 3D space, angular momentum, Euler equations.

Advanced Thermal Systems

* 1. Theory of conduction heat transfer
  2. Theory of laminar and turbulent boundary layers.
  3. Theory of convective heat transfer
  4. 3-dimensional flows: Navier-Stokes equation, "cold" CFD, energy equation
  5. Two-phase flows, sprays, evaporation
  6. Intro to CFD modelling including energy equations.

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**Module Title:** Research and Applications of Machining Processes

**Module Code:** 33342

**Semester:** 2

**Credits:** 20

**Level:** LM

**Module Description:**

Part A: Research and Development:

The aim of part A of the module is to give students an appreciation of recent research developments and acquaint them with the latest manufacturing process/technology results applicable to a range of industries, not least the aerospace sector. In addition to standard lectures, a practical laboratory session is incorporated to demonstrate various workpiece surface integrity evaluation techniques.

SYLLABUS

* Machining of advanced workpiece materials (tool life, workpiece roughness / integrity, operational features)
* Advanced titanium and nickel-based superalloys including shape memory alloys
* Carbon fibre composites and multilayer stacks
* New machining technologies
* Point grinding
* Hybrid machining approaches (electrolytic grinding, ultrasonic assisted processes etc.)
* ED dressing and ELID
* Creep feed / VIPER grinding including case studies
* Micro machining relating to HSM and EDM
* Minimum damage WEDM
* Process modelling
* Cutting processes (2D/3D including associated work on surface integrity modelling)
* Practical laboratory involving workpiece surface integrity assessment of machined surfaces (e.g. surface roughness, microhardness, microstructure alteration etc.)

Part B: Application:

The aim of Part B of the module is to consider the specific programming strategies, tooling, data acquisition and control technologies to support modern machining systems. SYLLABUS:

* Design for manufacture
* Computer aided manufacture (CAM) versus conversational programming
* Automatic machining algorithms
* Tool and part probing integration
* Closed-loop machining versus adaptive control strategies and condition monitoring
* High-speed machining concepts
* 3 axes versus 5 axes machining strategies
* Metrology and geometrical accuracy inspection
* Statistical process control and six sigma
* Practical demonstration

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**Module Title:** Intelligent Automation

**Module Code:** 33354

**Semester:** 2

**Credits:** 20

**Level:** LM

**Module Description:** The module is divided into two parts.

In the first part, biologically-inspired computational intelligence methods will be analysed, and their applications to engineering and automation will be shown. This part will introduce the basic concepts of approximate reasoning, collective and decentralised intelligence, and present a number of cutting edge nature-inspired Swarm Intelligence paradigms, as well as well-established techniques such as Evolutionary Algorithms, Simulated Annealing, Neural Networks, and Fuzzy Logic.

In the second part, the fundamental concepts of robotics will be presented. The second part of the module covers robot kinematics, dynamics, and control. It includes two hours of seminars where real robotics applications will be discussed by Mechanical Engineering members and invited speakers.

The use of computational intelligence methods to solve robotics problems will be shown.

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**Module Title:** Advanced Fluids and Powertrain Systems

**Module Code:** 33366

**Semester:** 2

**Credits:** 20

**Level:** LM

**Module Description:** The aim of the module is to provide the opportunity for the students to study advanced aspects of clean and sustainable energy storage and propulsion systems and to apply their CAE skills on a project that requires the integration of knowledge and skill accumulated in the whole programme of study.

Syllabus details:

1. Powertrain system, performance parameters, testing, modelling
2. Gas exchange and combustion processes in internal combustion engines. Adiabatic temperature, dissociation, equilibrium, kinetics of combustion, turbulence
3. Pollutant emissions formation and depletion, well to wheel assessment
4. Regulatory Framework. Advances in powertrain systems based on combustion technologies (2h lecture)
5. Advanced combustion strategies (i.e. low temperature combustion)
6. Alternative fuels, fuel reforming and exhaust after-treatment systems
7. Alternative powertrains including electric vehicles and hybrid powertrain configurations

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# Civil Engineering

**Module Title:** Geotechnical Engineering 1

**Module Code:** 29651

**Semester:** 1

**Credits:** 20

**Level:** LI

**Module Description:**

* Engineering Soil: (Geology for engineers, 3-phase model of soil, soil descriptions and classification).
* Compaction: (compaction theory, compaction testing, earthworks).
* Stress in soils (vertical and horizontal stresses, states of shear, Mohr’s circles of stress, effective stress).
* Seepage: (Hydraulic head, Darcy’s law, permeability and its measurement, flow through layered soil, flownets, piping, drainage and groundwater control)
* Compression and consolidation: (Compression and consolidation, Consolidated states, laboratory testing, 1-D theory of consolidation, settlement predictions)
* Shear strength: (Shear failure (Peak, ultimate and residual), Mohr-Coulomb criterion, undrained vs. drained shear, laboratory testing).
* Site Investigation: (Stages of a SI desk study, exploratory investigations (trial pits and boreholes), soil samples, Field tests (plate bearing tests, SPT, cone penetration test and their uses, SI reports).
* Basic Geotechnical design: (Geotechnical parameters, design charts and correlations, use of simple charts in parameter estimation)

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**Module Title:** Structural Engineering 1

**Module Code:** 29654

**Semester:** 1

**Credits:** 20

**Level:** LI

**Module Description:** The module covers the following topics in theory and design of structures.

Theory:

* 2-d stresses, Mohr's circle
* Yield and failure criteria in 2D and 3D
* St Venant’s principle
* Buckling of struts
* Plastic collapse
* Energy methods: displacements in pin jointed frames and energy in bending
* Behaviour and analysis of two-pinned and three-pinned arches
* Behaviour and analysis of cables

Design:

* Introduction to limit state design
* Steel: design of restrained beams, short and slender columns under axial load only
* Reinforced Concrete: design of elements in flexure (single and double reinforcement), shear design of reinforced concrete beams, design of short columns subject to axial load only.

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**Module Title:** Construction Practice and Management

**Module Code:** 29649

**Semester:** 2

**Credits:** 10

**Level:** LI

**Module Description:** This module comprises the following main subject areas: Introduces the key aspects of modern construction management:

* 1. Construction Management - comprises construction planning techniques, and the preparation of construction contract documentation.
  2. Health and Safety discusses the concepts of hazard and risk, with specific reference to construction sites.
  3. Introduction to Building Information Modelling, including the role of computer aided drafting.

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**Module Title:** Materials Engineering 1

**Module Code:** 29653

**Semester:** 2

**Credits:** 20

**Level:** LI

**Module Description:** Building on material science taught in Year 1 (Engineering Materials (04 28605), the aim of the module is to develop sound fundamental knowledge of the main construction materials and, through this understanding, enable their cost-effective engineering performance and sustainable use in practice. The use of case studies is adopted to develop a wider appreciation of the scope of materials engineering. CEN standards and sustainability issues are addressed throughout the teaching of this module.

Five materials, concrete, steel, masonry, timber and bituminous mixtures, form the main core of the materials engineering are taught in Years 2, 3 and 4. Additionally, a series of relatively new, novel and innovative materials and applications are covered during the three years of the degree course.

1. Concrete: The basics, those underpin performance of concrete; the constituent materials, their characteristics and practical relevance to concrete performance. Fresh and hardened concrete properties, their role and significance in construction; mix design, quality control and assurance procedures. Permeation properties and their role in determining engineering properties and different durability aspects of concrete.
2. Steel: Building on the metallurgy lessons of Year 1, explore the properties of different type of steels in construction, hot-rolled, cooled-rolled, stainless, concrete reinforcement and pre-stressing. Corrosion and principles behind the methods used to prevent corrosion in different environments (i.e. paint protection, cathodic protection).
3. Masonry: Different types of masonry units (clay bricks, calcium silicate bricks and concrete blocks) and mortars; manufacture, properties and applications; explore basic design and specification of masonry structures/reinforced masonry; workmanship issues; trends towards off-site fabrication of masonry units.
4. Group Project/Laboratory Work: Supported by laboratory work, students to undertake a series of coordinated small projects covering various aspects of the taught course.
5. CES EduPack software, is introduced, for use as information repository providing basic materials properties and performance, including sustainability.

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**Module Title:** Structural Engineering 2

**Module Code:** 28468

**Semester:** 1

**Credits:** 20

**Level:** LH

**Module Description:** This module has two main parts: Structural Design and Structural Analysis.

Five aspects of Structural Design are covered in this module as follows:

* 1. Structural steelwork:
     + Steelwork connections: introduction to simple bolted and welded connections, geometric considerations, methods of analysis of bolt groups and weld groups
     + Buckling and strength of steel columns: elements subjected to axial load and bending, effect of imperfections and end conditions, columns in frames

1. Reinforced Concrete
   * + Elastic analysis: column design - axial load and moment and slender columns
2. Composite construction:
   * + Analysis of composite sections, effect of construction sequence on composite action, shear at interface.
3. Timber
   * + Structural design of timber, timber strength classes, load duration and service class, design of timber beams and joists
4. Masonry
   * + Materials and material properties, calculation of unit strength and mortar grade required to carry vertical loads

The Structural Analysis part consists of two aspects:

* 1. Analysis of simple structures:
     + Bar and beam system will be analgised using the matrix displacement methods based on the principle of minimum potential energy.
  2. Introduction to the general Finite Element Analysis method:
     + 2D and 3D finite element models will be developed for truss and frame structures.

The following items will be covered in the Structural Analysis part:

* General expressions of strains and stresses in a bar and a beam.
* General expression of strain energy of bars and beams in terms of displacement variables.
* Principle of minimum potential energy.
* Concept of nodes, elements, nodal displacements, nodal forces and nodal degree of freedom.
* Derivation of stiffness matrices for bar element and beam element.
* Transform of element stiffness matrix from local to global coordinate systems.
* Assembly of element stifnness matrices.
* Concept of nodal internal and external forces and assembly of nodal forces.

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**Module Title:** Open Channel Flow Hydraulics

**Module Code:** 34279

**Semester:** 2

**Credits:** 10

**Level:** LI

**Module Description:** This module builds on the background provided in Fluid Mechanics to investigate practical Hydraulic Engineering problems. The module is focused on open-channel flow Hydraulics, i.e., how water is conveyed in contact with the Earth’s atmosphere. This affects many different flows of environmental and engineering relevance, such as rivers, artificial canals and irrigation networks, sewers, and even many types of flows originated in floods.

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**Module Title:** Industrial Project 1 (Civil Eng)

**Module Code:** 23633

**Semester:** 1

**Credits:** 20

**Level:** LH

**Module Description:** The student will undertake a placement with a host company or organisation to apply, as appropriate, the knowledge, theory and skills developed on the degree programme in a practical ‘real world’ setting. It is expected that each student will understand the context in which the work is being executed. In the execution of their work each student will experience the constraints imposed by General Legislation, Health & Safety, Risk Management, Process controls, Sustainability and Environmental issues.

Students will complete an inception report within the first two weeks of the placement, in which they identify the work to be carried out and initial expectations of objectives and learning which will be achieved. Ideally this will be completed in consultation with the placement supervisor.

Throughout the placement the student will maintain a personal diary and log of the experience gained, using a pro-forma provided and which is based on professional institutional development objectives.

Assessment is based on information to be provided by the placement host on the student’s performance and professionalism (10%), final report (50%), the personal log (20%) and a presentation (20%), in which the student describes the work carried out and the experience gained.

Key elements of the Final Report will be demonstration of how the agreed learning outcomes were achieved and a reflection on the enhanced understanding gained of the fundamental principles taught in first and second year.

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**Module Title:** Geotechnical Engineering 2

**Module Code:** 29645

**Semester:** 1

**Credits:** 20

**Level:** LH

**Module Description:** The objective of this module is to build on the material taught in the 2nd year Soil Mechanics module and introduce geotechnical engineering applications. These applications will consist of shallow and deep foundation design, retaining structures, slope stability, problematic soils and geotechnical engineering in urban environments.

More specifically the module will deal with:

Semester 1

* 1. Introduction to Geotechnical Engineering: Role of soil mechanics, geotechnical parameters, introduction to EC7.
  2. Shallow Foundations: Bearing pressure, bearing capacity, design principles, settlement predictions, settlement criteria.
  3. Deep Foundations: Piling (bored, driven and caissons), single pile design, piles in sands and clays, pile group behaviour and pile group design, pile testing.

Semester 2

* 1. Retaining structures: Horizontal stresses, Rankine’s and Coulomb’s theories, Gravity retaining walls, cantilever retaining walls, propped and anchored walls.
  2. Slope stability: Natural slopes, cut slopes and embankments, design principles, role of ground water and pore water pressures, design methods and design charts.
  3. Problematic soils: contaminated land assessment and remediation; engineering behaviour and treatment of expansive soils; other problematic ground conditions (collapsibility, highly compressible soils, organic soils, glacial and periglacial soils).
  4. Geotechnical Engineering in urban environments: use of underground space, geotechnical consideration for use of underground space, utility provision, introduction to tunnelling, future challenges for geotechnical engineering.

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**Module Title:** Materials Engineering 2

**Module Code:** 29647

**Semester:** 2

**Credits:** 20

**Level:** LH

**Module Description:** The aim of the module is to widen the knowledge base, and deepen the understanding of construction materials from that taught in Materials Engineering 1 module in Year 2, so as to make the best use of the materials in terms cost effectiveness and environment impact. The use of case studies, including failure of structures are adopted to widen the scope of materials engineering. CEN standards and sustainability issues to be addressed throughout the teaching of this module.

1. Concrete: The basics of breakdown of the material structure. Physical and chemical mechanisms of concrete deterioration, covering shrinkage, thermal expansion, freeze-thaw, abrasion, sulfate attack, alkali-aggregate reactions, acid attack and corrosion of reinforcement (carbonation and chloride induced). Specification and design of durable concrete structures and serviceability. Repair and maintenance of concrete.
2. Timber: Types and their use; production; properties and use of solid timber. Processed timber products (including Glulam and composites strengthened by synthetic materials such as carbon-fibre, GF, etc. and their durability. Explore the design and specification of timber for structural application.
3. Bituminous Mixtures: Binders, type, characteristics and engineering properties. Bitumen-aggregate mixtures, load carrying mechanisms; type of pavements, mix requirements, engineering properties and durability. Design of bitumen-aggregate mixes, type of specifications and principles of design, continuous graded mixes, hot-rolled asphalt and new developments.
4. Group Project/Laboratory Work: Supported by laboratory work, students to undertake a series of coordinated small projects covering various aspects of the taught course.
5. CES EduPack software, use is developed further to provide advanced materials properties and performance, including sustainability.

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**Module Title:** Surface and Groundwater Hydrology

**Module Code:** 34300

**Semester:** 2

**Credits:** 10

**Level:** LH

**Module Description:** This module will develop students’ understanding of hydrological processes with a specific focus on the surface water and hydrogeological domains. It will illustrate the practical applications of hydrology and hydrogeology and will cover:

* The hydrological cycle and its components.
* Precipitation processes, types and measurement.
* Surface water flow.
* Hydrograph analysis.
* Rainfall runoff modelling and the Rational Method.
* Storage routing.
* Channel routing.
* Introduction to Groundwater flow.
* Darcy’s Equation.
* Introduction to flow through aquifers.
* Introduction to well hydraulics.
* Confined and unconfined aquifers.
* Steady state well hydraulics.
* Pumping test analysis.

This module provides students with the skills necessary to perform hydrologic modelling and water resources management by increasing students’ quantitative analytical skills.

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**Module Title:** Soil Mechanics

**Module Code:**  NEW

**Semester:**  1

**Credits:** 20

**Level:** LM

**Module Description:** This modules covers the following:

* Physical Properties of Soils, Description of an assemblage of particles; properties of coarse grained soils; clay mineralogy; properties of fine grained soils; clay shrinkage and trees; frost heave, principle of effective stress for saturated and partially saturated soils.
* Importance of seepage; groundwater head and Darcy’s Law; general equations for seepage flow; boundary conditions; flow nets; radial flow theory; laboratory permeability tests; field permeability tests and interpretation of test results. Groundwater control using groundwater extraction and exclusion techniques
* Concepts of anisotropic and isotropic consolidation and compression; overconsolidation ratio; preconsolidation pressure; prediction of settlement; Terzaghi’s theory of consolidation; isochrones; finite difference methods for consolidation problems; calculation of immediate and consolidation settlements, creep settlement, collapse settlements
* Fundamental theory of stress and strain, drained and undrained shear tests on normally consolidated clays, Dilatancy theory, drained and undrained shear tests on heavily overconsolidated clays, wet and dry soils, Failure criteria, stress paths analysis
* Routine soil tests interpretation, index tests, Mohr-Coulomb failure criterion, one-dimensional and three-dimensional compression, undrained shear strength, pore water pressure coefficients
* Critical State Soil Mechanics: Critical State Framework, establishment of State Boundary Surface, Roscoe Surface for normally consolidated clays, normalized q & p/ plots, the Hvorslev surface, sands and the critical state model
* Routine soil tests interpreted according to the critical state model

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**Module Title:** Industrial Project 2 (Civil Eng)

**Module Code:** 23634

**Semester:** 1

**Credits:** 20

**Level:** LM

**Module Description:** The student will undertake a placement with a host company or organisation to apply, as appropriate, the knowledge, theory and skills developed on the degree programme in a practical ‘real world’ setting. It is expected that each student understand the context in which the work is being executed. This will include the business need to be successful and generate income; and the operational business processes and procedures in a national and international framework. In the execution of their work each student will experience complex external inputs from co-workers, suppliers, consultants and the constraints imposed by General Legislation, Health & Safety, Risk Management, Process controls, Sustainability and Environmental issues.

Students will complete an inception report within the first two weeks of the placement, in which they identify the work to be carried out and initial expectations of objectives and learning which will be achieved. Ideally this will be completed in consultation with the placement supervisor.

Throughout the placement the student will maintain a personal diary and log of the experience gained, using a pro-forma provided and which is based on professional institutional development objectives.

Assessment is based on information to be provided by the placement host on the student’s performance and professionalism (10%), final report (50%), the personal log (20%) and a presentation (20%), in which the student report and reflects on the academic aspects the work carried out and the experience gained.

Key elements of the Final Report will be demonstration of how the expected learning outcomes were achieved and a literature review related to an element of depth within the project.

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**Module Title:** Advanced Structures and Design

**Module Code:** 25427

**Semester:** 1

**Credits:** 20

**Level:** LM

**Module Description:** The module covers advanced concepts of materials and design used in the Civil Engineering construction industry.

The module also considers advanced aluminium and pre-stressed concrete structures. It addresses the structural use of aluminium and pre-stressed concrete according to the Structural Codes, the design principles of the respective structural members and simple structures, as well-as the connections used.

The module also covers aspects of bridge maintenance and management including: deterioration mechanisms, testing and investigations of concrete bridges.

The module first considers the theoretical framework that governs the sustainable development. The basic principles of sustainable development that have to be incorporated into the design of structures and construction process are presented.

The principal directives and standards on the sustainable design of structures are presented and associated to the assessment of structures with respect to sustainability criteria.

In addition, the module covers one of the significant factors to obtain a sustainable development: renewable energy systems. The module focuses on the design of wind energy structures and in particular, onshore wind turbine towers; certain critical details of the design of such structures will be also presented.

The module covers the principles and the design methods of prestressed concrete members and structures

The module also covers aspects of bridge maintenance and management including: deterioration mechanisms, testing and investigations of concrete bridges.

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**Module Title:** Rural Roads

**Module Code:** 26530

**Semester:** 1

**Credits:** 10

**Level:** LM

**Module Description:** The course provides an introduction to the topic of building and maintaining rural roads for development and includes:

* The contribution of rural roads to growth and poverty reduction
* Analytical framework for understanding rural transport
* Pro-poor transport appraisal including methods for capturing non-monetary benefits
* Rural road design and construction
* Labour-based & intermediate technologies
* The implications of climate change
* Rural transport services
* Recent research developments in rural roads

The course will include laboratory sessions to better understand simple tests which can be used in the field to determine soil properties required for proper design and maintenance.

The above concepts will be cemented via a major piece of practical coursework.

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**Module Title:** Ground Investigation

**Module Code:** 27094

**Semester:** 1

**Credits:** 20

**Level:** LM

**Module Description:**

* 1. Geology for Engineers, including igneous, sedimentary and metamorphic rocks, geological sections, geological maps and sections, geological map interpretation, and structures: natural slopes; folds; faults.
  2. Engineering Geology, including Processes: tectonics; sea-level change; weathering; mass movement and Environments: fluvial; aeolian; glacial and periglacial; coastal, floodplains and alluvium and mining subsidence.
  3. Introduction to rock engineering, including: rock descriptions, rock strength and rock mass strength.
  4. Aims of site investigation, stage planning; desk study.
  5. Exploration: trial pits, boreholes; geophysical methods; soil sampling, sampling disturbance, soil classification.
  6. Ground Investigations: conduct and interpretation of field tests including static cone and Standard Penetration Testing, vane test, pressuremeter and plate loading tests; analysis, correlation and presentation of results, swelling clay soils, location of mine voids and shafts.
  7. Instrumentation: instruments and gauges, measurements: load, pressure, groundwater and pore water pressures, and deformations.

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**Module Title:** Geotechnical Engineering 3

**Module Code:** 29657

**Semester:** 1

**Credits:** 20

**Level:** LM

**Module Description:** This modules covers the following:

1. Computer Aided Engineering
   * Use of the computer package (i.e. ABAQUS or similar)
   * Use of computer package for slope stability calculation
   * Use of computer package for retaining wall stability calculation
   * Use of finite element analysis for simple problems such as behaviour of soil under triaxial conditions
2. Critical State Soil Mechanics

* Critical State Framework, establishment of State Boundary Surface, Roscoe Surface for normally consolidated clays, normalized q & p/ plots, the Hvorslev surface, sands and the critical state model
* Routine soil tests interpreted according to the critical state model
* Behaviour of soils before yield, introduction to plasticity and soils, Cam-Clay theory, calculation of elastic and plastic strains

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**Module Title:** Materials Engineering 3

**Module Code:** 29659

**Semester:** 1

**Credits:** 20

**Level:** LM

**Module Description:** Continuing from the Materials Engineering taught in years 2 and 3, the aim of this module is to extend the scope of the subject to include the understanding of advanced, novel and innovative developments within the realm of construction material, using, as much as possible, case studies and forensic engineering principles to develop wider appreciation of the materials engineering. CEN standards and sustainability issues to be addressed, as a requirement, throughout the teaching of this module.

1. Concrete: High performance concrete, high consistence and self-compacting, high and ultra-high strength, high durability i.e. chloride and sulfate resistant, self-cure; fibre-reinforced concrete pumped concrete. Light-weight concrete; heat-resistant concrete; high-density and radiation-shielding concrete; sprayed concrete; underwater concrete; concreting large pours; alternative reinforcement for concrete; recycled concrete. Coatings for concrete. Specific requirements examination of reinforced concrete durability. Design life prediction in hostile climates and quality control processes. Explore the deterioration of reinforced concrete structures, the methods of inspection, testing and repair to extend the service life and restore the value of the asset. Include asset management principles as related to engineering more life from existing structures to improve the sustainability footprint.
2. Composites: Develop the principles of materials to develop composite solutions for the new-build or the strengthening of existing structures by use of resin-fibre composites. Examine composite structures made using pultruded or extruded resin fibre structural elements reinforced with glass, aramid or carbon fibre and options to build bridges or bridge enclosures with these materials. Explore the strengthening of structures using bonded plates of glass or carbon fibre bonded to steel, concrete or other surfaces to increase strength. Examine the properties of the resins (principally epoxy) to make the composites and understand their limitations
3. Protection: Building on the knowledge of resins, examine the specification and performance for the surface protection systems (hydrophobic, impregnating and film-forming) for concrete structures, including silane, acrylic, epoxy, polyurethane and other materials commonly used to protect concrete. Exposure environments will include protection against attack from carbonation, chloride ingress, sulphate attack and high specification systems for acid/chemical resistance, crack bridging and reinforcing coatings and elastomers.
4. Specialist: develop the applications for structural aluminium and structural glazing and composites and explore the structural properties of the materials. Refresh the properties of ceramics, including masonry, and cast stone.
5. Group Project/Laboratory Work: Supported by laboratory work, students to undertake a series of coordinated small projects covering various aspects of the taught course.
6. EduPack. The module also develops further the capability of this software, providing advanced materials properties and performance, including sustainability.

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**Module Title:** Experimental and Numerical Techniques in Structural Engineering

**Module Code:** 30588

**Semester:** 1

**Credits:** 20

**Level:** LM

**Module Description:** This module provides students with the opportunity to tackle real life structural modelling and assessment challenges. It intends to bring all students to a similar level as far as understanding structural behaviour is concerned. It comprises three complementary parts: structural assessment, nonlinear finite element modelling and experimental testing.

Students will use state-of-the-art methods from the extant literature to assess the load carrying capacity of structural configurations not adequately covered by current codes of practice. They will then develop nonlinear finite element models to predict the detailed structural behaviour of the assessed members. Physical tests will then be carried out on the same structural members. The experimental results will be used to enhance understanding of structural behaviour and highlight the strengths and limitations of both assessment and finite element models.

Lectures, workshops and/or seminars will be delivered to provide support at key stages of the module. These sessions will cover:

1. Structural behaviour and assessment
2. Nonlinear finite element modelling
3. Health and Safety aspects within the context of physical testing

Students will ultimately produce written reports that demonstrate full integration of the experimental, modelling and assessment tasks.

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**Module Title:** Civil Engineering Group Management Project A

**Module Code:** 33098

**Semester:** 1

**Credits:** 10

**Level:** LM

**Module Description:** Group Management Project A involves planning, administration and management of laboratory and fieldwork exercises across UG/PGT Programmes, under the general supervision of the academic staff with overall responsibility for the exercises and liaising with appropriate technical staff. Assignment of tasks to individuals and details of work programmes, supporting services, ancillary activities and implementation will lie largely with the group, in conformity with the objectives and overall requirements of the exercises.

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**Module Title:** Wind Engineering and Bluff Body Aerodynamics

**Module Code:** 34311

**Semester:** 1

**Credits:** 20

**Level:** LM

**Module Description:** The module provides an introduction to the field of wind engineering and bluff body aerodynamics, through development of key principles which are in turn complemented by in-depth examples and applications drawn directly from industry and current academic research. The module covers a broad introduction to the following topics:

Principles (18 lectures)

* Atmospheric basics: basic meteorology, types of weather and wind systems, including synoptic and non-synoptic winds. Characteristics of the wind near the ground. Atmospheric stability effects. Statistical analysis of wind. Climate change considerations. Experimental, computational and analytical tools. Risk, resilience and social considerations. Introduction to bluff body aerodynamic and general aerodynamic considerations.

Applications (22 lectures)

* Wind loading on buildings from both a static and dynamic approach. Wind loading on buildings for extreme winds. Pedestrian comfort. Natural and forced ventilation of buildings. Wind energy resource and energy generation. Air quality and dispersion of atmospheric pollutants. Weather effects on transportation systems and the pedestrian environment. Vehicle aerodynamics considerations.

A series of laboratory classes (3 classes) and seminars (1 session) supplement the lecture components of the course to provide a deeper understanding of the content.

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**Module Title:** Construction Management

**Module Code:** 16196

**Semester:** 2

**Credits:** 20

**Level:** LM

**Module Description:** The module has the following components:

* Project Management deals with: Project management- concept, project team organisation, key principles, in-house or external provision; Setting project objectives, Risk management and allocation; Contract strategy- work packages, payment systems, organisational systems, contractor selection; the role of the New Engineering Contract.
* Construction and Project Planning uses examples to distinguish between the art of planning and the application of scientific planning techniques. Planning techniques addressed include: Bar charts; Time location charts; Line of balance charts; Networks (Precedence and Arrows) and Resources; Crashing; Overlapping activities; Updating Networks; Monitoring and reporting progress; Advanced network planning; and an introduction to the principles of lean planning.
* Contract Procedures provides an introduction to construction contract documentation and procedures within the UK legal system. It addresses how recent UK best practice (as encompassed, for example, in the New Engineering Contract 3rd ed) compares and contrasts with conventional contracts (as encompassed in the FIDIC and JCT Conditions of Contract). Specific topics addressed in detail include: Roles of the parties, contract preparation and administration, dealing with change, and resolution of disputes.

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**Module Title:** Engineering Production and Risk Management in Construction

**Module Code:** 20474

**Semester:** 2

**Credits:** 20

**Level:** LM

**Module Description:** This module comprises two main subject areas: Engineering Production in Construction, and Construction Project Risk Management.

Engineering Production introduces and discusses the main drivers for change in the construction industry over the last decade, and the techniques which have been, and are being developed to identify and manage improvements in value and decrease in waste of all kinds. Topics addressed include Managing the Process, Managing Quality, Managing Value, Managing Waste, Managing People and Relationships, and Managing Time.

Construction Project Risk Management discusses the concepts of risk and hazard, principles and best practice, lessons learnt from construction disasters, treatments of construction project risks, project risk management tools and techniques (Qualitative and Quantitative Methods), guidance in practical risk management (case studies) and legal aspects. Students will be shown how the application of these techniques enables a better understanding of project risk at all stages of the project, enabling improved design, construction and operation.

**Module Title:** Road Economics and Financing

**Module Code:** 25970

**Semester:** 2

**Credits:** 20

**Level:** LM

**Module Description:** Road Financing that deals with the options available for funding road network maintenance and development, ranging from government sources, private sector and international agencies. It examines the establishment of road funds, integrity in road financing and management, budget support, private road financing, toll roads, public private partnerships.

Road Economics covers the following topics: Demand, Supply, Consumer and producer Surplus, Principles of Transport Appraisal Theoretical basis of Cost-Benefit analysis, Traffic Type and Traffic Volume Forecasting, Summary Project Performance Measures and Their Use in Making Investment Decisions, Vehicle Operating Cost (VOC) Savings, Valuing Travel Time Saving Benefits Costing Road Accidents Shadow Pricing Financial vs. Economic Appraisal Risk and Uncertainty in Transport Appraisal.

Road Project Appraisal deals with the practical application of principles of economic appraisal through the use of the World Bank's de facto standard for road investment appraisal, HDM-4 to assess the viability of proposed road projects, prepare work programmes, and develop road network strategies and policies. Students will be taught the components of the system and then be asked through a self-learning exercise to use the tool to investigate a number of scenarios.

Module Title: Road Design and Planning

Module Code: 28090

Semester: 1

Credits: 20

Level: LM

**Module Description**: The module covers two related topics.

• Traffic Engineering covers the principles and practice of road traffic engineering and planning.

• Highway Design and Capacity covers the errors associated with design traffic volumes, the procedure for calculating the capacity of highway links, geometric designs and standards, design speed and junction design and capacity.

Module Title: Pavement Engineering

Module Code: 35386

Semester: 1

Credits: 10

Level: LM

**Module description**: The module covers the following.

• Pavement design covers the concepts of empirical and analytical pavement design. It also covers pavement structural evaluation that addresses the concept of assessing the structural condition of pavements, selecting appropriate maintenance treatments and designing overlays.

• Pavement analysis covers material characterisation, pavement response, Hooke’s law, the Method of Equivalent Thickness (MET), pavement performance and analysis of pavement defects.

• The design and performance of the drainage systems of roads and their impact on the performance of pavements by considering fundamentals, design-erosion control, design factors, Influence of road geometrics, pavement surface/shoulders/kerb flow, longitudinal drainage, transverse drainage.

Module Title: Road Asset Management

Module Code: 17835

Semester: 1

Credits: 20

Level: LM

**Module description**: The module addresses the principles and methodologies used for maintenance management or road network and institutional issues of road asset management. It covers current engineering-driven issues associated with the management of the maintenance of the road assets. It considers the different types of management systems available today and the components of such systems. Distinction is made between the Network, Works Programming, Project and Operations levels of management. In connection with this it considers the types of data that are required for the efficient management of road maintenance and the issues associated with the collection, integrity, storage and analysis of such data. The module also examines the issues of setting and assessing standards and strategies for road maintenance management, monitoring the performance of pavements as well as the performance of the management systems employed. Furthermore, it covers the principles followed for the appropriate treatment selection and prioritisation of pavement maintenance programmes. Other aspects related to road asset management include demand management, predicting demand, assessing financial cash-flows, failure mode analysis, risk assessment and management, optimised decision-making (including life-cycle costing) and asset valuation. Institutional issues deal with the structures for road administration including the development of a road policy framework, finance, institutional development and management, ownership and responsibility, systems implementation and development.

**Module Title:** Seismic Engineering

**Module Code:** 26640

**Semester:** 2

**Credits:** 20

**Level:** LM

**Module Description:** Aim: Introduction to, and application of, key elements of structural dynamics, associated methods of analysis and key design concepts with practical applications to earthquake engineering

Syllabus:

1. Introduction to dynamics and its effect on structures - seismic loading, wind loading, storm wave loading and blast loading. Analytical solution to Single Degree of freedom system, concept of resonance and damped dynamic system.
2. Multiple degrees of freedom system, approximate energy method, simple eigenvalue analysis using beam finite element.
3. Finite element method for dynamic analysis: Eigenvalue system, explicit and implicit time stepping scheme. Introduction to simple non-linear elasto-plastic finite element analysis.
4. Seismic engineering - Introduction to the cause of earthquake, earthquake loading and key design concepts including design spectrum and ductility. Introduction to Eurocode 8, q factor, analysis of steel and RC structure according to Eurocode 8, earthquake resistant design including mitigating methods such as base isolation, tuned mass damper and viscous damper.
5. Combination of structural dynamics with design concepts on earthquake resistant design to form a consistent methodology for structural analysis and design.
6. Estimation of the rotational period of soil-structure frames and the definition of modified seismic forces dues to the rocking motion of the soil.
7. Wind Engineering - Wind induced vibrations and aeroelastic instabilities, basic turbulence, key design concepts and mitigation methods. Wind effects on high rise buildings, chimneys and masts as well as bridges.

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**Module Title:** Structural Engineering Practice

**Module Code:** 26925

**Semester:** 2

**Credits:** 20

**Level:** LM

**Module Description:** Learning and teaching is structured around the Institution of Structural Engineers (IStructE) Core Objectives for Chartered Membership. These Core Objectives detail the requirements for Initial Professional Development (IPD) for candidates intending to qualify as Chartered members of the IStructE. The module will cover the following topics:

* The IStructE: its history, role, and code of conduct;
* Structural materials;
* Environmental and sustainability issues and legislation;
* Construction systems and techniques;
* Law and statutory legislation in structural engineering practice;
* Health and Safety requirements and legislation;
* Commercial and financial constraints and their impact on structural engineering practice;
* Whole-life costing;
* Value engineering;
* Procurement routes and forms of contracts;
* Quality systems in structural engineering practice;

Learning in this module consists of lectures interspersed with seminar tutorials and workshops.

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**Module Title:** Structural Engineering 3

**Module Code:** 28465

**Semester:** 2

**Credits:** 20

**Level:** LM

**Module Description:** The module covers advanced topics in structural materials and composite construction including:

1. Advanced Structural Materials
2. Structural Repair
3. Composite Construction
4. Prestressed Concrete Structures
5. Large Displacement Behaviour

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**Module Title:** Civil Engineering Group Management Project B

**Module Code:** 33099

**Semester:** 2

**Credits:** 10

**Level:** LM

**Module Description:** Group Management Project B strengthens planning, administration and management skills obtained in Group Management Project A while enabling developing further management and communication skills through student-led learning. The Group Management Team will support training of UG students who work on their projects on the use and integration of BIM (Building Information Management), under the general supervision of the academic staff with overall responsibility for the exercises and liaising with appropriate technical staff.

Assignment of tasks to individuals and details of work programmes, supporting services, ancillary activities and implementation will lie largely with the group, in conformity with the objectives and overall requirements of the exercises.

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# Railway Engineering

**Module Title:** Railway Infrastructure Engineering

**Module Code:** 26931

**Semester:** 1

**Credits:** 20

**Level:** LI

**Module Description:** Students will learn about the fundamental structural components of the railway track and how they are designed to withstand the effects of train and environmental forces so that the railway foundation is adequately protected and train / track operating costs, passenger comfort and safety are kept within acceptable limits. To this end the module will consist of topics related to the track structure as a whole and its components parts including the rails, fastenings, sleepers, ballast, the formation and subsoil. Switches and crossings and the overhead line electrification system will also be covered. Aspects of concreted (slab track) will also be addressed. Consideration will also be given to appropriate track maintenance.

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**Module Title:** Railway Traction

**Module Code:** 26933

**Semester:** 2

**Credits:** 20

**Level:** LI

**Module Description:** This module introduces students to components and systems used for diesel-powered and electrically-powered railway traction. It will cover all aspects of railway traction, including both AC and DC electrification systems, together with an analysis of the different options which are available for traction packages. These will include both AC and DC traction drives, and treatment of the operation of the necessary power electronic converters which are required to modulate the power received from the primary source.

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**Module Title:** Railway Management and Control

**Module Code:** 31380

**Semester:** 1

**Credits:** 20

**Level:** LH

**Module Description:** This is an advanced module that provides core competencies in railway operations and management, including the principles and practice of timetabling, underlying economic considerations and high-level operating principles, together with railway signalling, train control, traffic management and communications principles and practice.

The railway signalling element will include consideration of fixed block systems as well as moving block. Advanced signalling systems, as used in the European Railway Traffic Management System, will be analysed. This will include communication-based train control.

Course material will include case studies on realistic railway systems and laboratory demonstration of railway signalling and operation simulations using advanced software, in preparation for the Railway Design Project.

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**Module Title:** Railway Design Project (BEng)

**Module Code:** 31378

**Semester:** 2

**Credits:** 20

**Level:** LH

**Module Description:** This module provides students with the opportunity to take on, as part of a team, real life conceptual designs drawn from Engineering Grand Challenges that address the railway industry, providing an opportunity to apply cross-disciplinary working to solve problems.

The project design aspects of the work will aim at enhancing students’ awareness regarding challenges imposed on the railway industry by key issues such as introduction of new technologies, regulation, managing a linear asset, climate change and sustainability, and the way these impact their role as engineers, working in teams.

Students will work together in cross-disciplinary teams to provide design solutions to railway engineering project scenarios using railway design simulation and modelling.

This module will be supported by a series of taught sessions run over semesters 1 and 2 to provide support at key stages of project work. These will target key requirements to deliver successful integrated projects designs. These sessions will include:

1. The systems engineering approach and design philosophy
2. Project Planning, management and effective team working
3. Health and Safety aspects and impact on design
4. Sustainability aspects of design, including stakeholder engagement; ethics; human factors
5. Why projects fail: nature of risk in working/business operations; risk management
6. Key aspects of railway design, management and control.

Teams will produce a simulation of a railway system as part of the final task.

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**Module Title:** Railway Design Project (MEng)

**Module Code:** 31379

**Semester:** 2

**Credits:** 20

**Level:** LH

**Module Description:** This module provides students with the opportunity to take on, as part of a team, real life conceptual designs drawn from Engineering Grand Challenges that address the railway industry, providing an opportunity to apply cross-disciplinary working to solve problems.

The project design aspects of the work will aim at enhancing students’ awareness regarding challenges imposed on the railway industry by key issues such as introduction of new technologies, regulation, managing a linear asset, climate change and sustainability, and the way these impact their role as engineers, working in teams.

Students will work together in cross-disciplinary teams to provide design solutions to railway engineering project scenarios using railway design simulation and modelling.

This module will be supported by a series of taught sessions run over semesters 1 and 2 to provide support at key stages of project work. These will target key requirements to deliver successful integrated projects designs. These sessions will include:

1. The systems engineering approach and design philosophy
2. Project Planning, management and effective team working
3. Health and Safety aspects and impact on design
4. Sustainability aspects of design, including stakeholder engagement; ethics; human factors
5. Why projects fail: nature of risk in working/business operations; risk management; conflict and time management
6. Key aspects of railway design, management and control.

Teams will produce a simulation of a railway system as part of the final task.

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**Module Title:** Advanced Topics in Railway Engineering

**Module Code:** 34507

**Semester:** 1

**Credits:** 20

**Level:** LM

**Module Description:** The advanced railway engineering module examines key concerns for railways in a global context. Students will consider the role of railways in meeting the UN’s Sustainability Development Goals including key aspects relating to sustainability, decarbonisation, emissions and urban development. The module will also look at the impact of emerging technologies specifically including railway digitisation, and will cover advances in modelling, simulation and data analysis techniques to advance the effectiveness and efficiency of rail systems.

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**Module Title:** Railway Synoptic Project

**Module Code:** 34508

**Semester:** 2

**Credits:** 20

**Level:** LM

**Module Description:** This module provides students the opportunity to apply the knowledge and skills gained through studying railways to a practical, real-world scenario. Through a synoptic challenge, students tackle a real-world railway industry problem to benefit the rail industry and embed their personal learning and understanding of railway engineering. Students will be expected to analyse the scenario, identify key issues, propose and ideally demonstrate through calculation and / or simulation a workable solution. The challenge brings together learning and knowledge of technical and non-technical aspects of railways, potentially including areas such as rolling stock, infrastructure, traction, train control, economics, and ergonomics.

The module is supported through external visits and engagement with potential stakeholders, allowing students to develop their communication and interpersonal skills, as well as their analytical and application skills.

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**Module Title:** Railway Operations, Management and Planning

**Module Code:** 34513

**Semester:** 1

**Credits:** 20

**Level:** LM

**Module Description:** This module provides the tools for examining critically the systems and subsystems that support rail-way operations and the associated planning functions. It allows students to develop a solid under-standing of the constraints and opportunities applicable to railway operations, including systems integration, timetabling, resource planning, maintenance and performance management, people and operational safety. The module also covers the governmental, financial, and societal contexts that influence railway operations and planning. The module is delivered through case studies, interactive lectures, and team activities to develop the knowhow and knowledge required to operate railways of all types. The teaching is supported by guest lecturers from industry.

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**Module Title:** Infrastructure and Rolling Stock Systems

**Module Code:** 34514

**Semester:** 1

**Credits:** 20

**Level:** LM

**Module Description:** This module provides a starting point for critically examining the systems and subsystems that make up railway infrastructure and rolling stock. The module describes the interfaces between these sub-systems and the other sub-systems of the railway. It allows students to develop a solid understanding of the technologies and components of railway infrastructure and rolling stock, including system and component design, performance under different operating conditions, installation, maintenance, and people. The module also covers the governmental, financial, and management issues that affect the rolling stock and infrastructure systems. The module is delivered through case studies, interactive lectures, and team activities to develop learning with support from guest lecturers from industry.

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**Module Title:** Railway Control and Digital Systems

**Module Code:** 34517

**Semester:** 1

**Credits:** 20

**Level:** LM

**Module Description:** This module allows students to gain a detailed knowledge and understanding of signalling, control, and digital systems within railways. It covers fundamental principles and concepts for the design, implementation, reliability, and maintainability of signalling and railway control systems, as well as other digital systems within railways, taking into account the essential requirements of cost, capacity and customer comfort, while minimising carbon output. Technical and operation considerations for railway systems, such as safety and information security are addressed throughout the module. Digital system analysis and synthesis techniques are also included, for example modelling and simulation, to enable a thorough understanding and application of railway control functions and digital systems.The module is delivered through case studies, interactive lectures, and team activities to develop the requisite knowledge, knowhow and skills, with support from guest lecturers from industry.

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**Module Title:** Electrification and Traction Systems

**Module Code:** 34515

**Semester:** 2

**Credits:** 20

**Level:** LM

**Module Description:** This module allows students to develop the knowledge, skills and knowhow that are necessary to specify and assess the requirements for the traction system for a particular type of train, the specific topology of the line or network to be served and the associated service pattern. The module covers the arrangements for the supply of energy to the train from a national grid or another power source, e.g., diesel, hydrogen or, battery etc., the onboard control and conditioning of the power to be supplied to the traction machines, the facilities for storing energy onboard and trackside, as well as the transmission of traction and braking forces. The module also deals with the fixed infrastructure needed to convert power from a national grid and to distribute it to AC or DC trains, using either overhead or ground-level electrification. Students learn to dimension both traction and braking systems to achieve the necessary acceleration and deceleration rates, creating digital models to validate the choices made. They acquire the knowhow to review the safety and sustainability of traction systems and supplies.The module is delivered through standard and interactive lectures, case studies, interactive lectures, and team activities provided by University staff, to develop knowhow and skills, with support from guest lecturers from industry and other relevant educational establishments.

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**Module Title:** Systems Engineering and Ergonomics

**Module Code:** 34516

**Semester:** 2

**Credits:** 20

**Level:** LM

**Module Description:** This module on systems engineering and ergonomics is designed to cover four main areas:

1. systems engineering approaches, management engineering, and project risk;
2. systems life-cycle engineering tools for reliability and performance;
3. safety cases and human factors;
4. ergonomic design concepts.

The module is intended to provide students with an understanding of the interfaces and interactions of the railways as complex and complicated systems. It covers hard and soft systems approaches, appropriate systems engineering tools, case studies and an in depth review of safety case theory and practice. The main technical issues that drive the design of components for the usability of systems required in the operation of a railway are also addressed in the lectures. Also addressed are tools to assess and mitigate the financial and organisational risks of major projects.

The module is delivered through case studies, interactive lectures, and team activities to develop learning with support from guest lecturers from industry. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Module Title:** Business and People Management

**Module Code:** 34518

**Semester:** 2

**Credits:** 20

**Level:** LM

**Module Description:** This module is intended to ensure students have sufficient understanding of business basics to enable them to work effectively at a senior management level within a business / railway business. The module covers the range of topics that would typically be addressed in a Master of Business Administration, but angled towards the needs and specifics of the rail industry. It gives students a grounding in topics such as basic economics, business strategy, investment appraisal, financial reporting, project management and governance, organisational culture and ethics, process and quality control, technology management, asset management and marketing. Railway specific topics include an understanding of how the UK rail industry is structured and funded on the grounds that the UK has one of the most complicated arrangements of any rail system world-wide. It also includes an introduction to understanding human behaviour, specifically angled towards the skills needed to manage staff in an effective manner.

The module is delivered through a series of lectures, reinforced by a small group team exercise based on a realistic business scenario, and an assignment that requires students to further develop and expand their appreciation and understanding. The lectures are of delivered by University staff, supported by a high proportion of guest lecturers from industry (both rail and non-rail). \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Module Title:** Railway Systems Synthesis C

**Module Code:** 21500

**Semester:** 2

**Credits:** 20

**Level:** LM

**Module Description:** This unit has been created to encourage students to develop, through in-depth independent study, their understanding and know-how in the areas of the class-taught modules associated with Railway Systems Synthesis C as co-requisites. The submissions made as part of this unit allow the assessment of the particular know-how and understanding.Students registered for this module are provided with 4 assignment briefs, each of which relates to one of the 4 class-taught modules that are the negotiated co-requisites for this unit. Additional information and guidance are provided as appropriate. 3 h face to face tutorials are arranged for full-time students for each of the 4 assignments, about 3 weeks after the respective class-taught unit. Part-time students may opt to attend the tutorial or may elect instead to use the telephone / e-mail support offered by the module leader for all students. Successful performance in this module requires that students identify and analyse additional literature and interview derived material, as well as other sources containing information relevant to the given topics.

All sources used must be referenced using the Harvard method, as specified in the guideline produced by the University of Birmingham Information Service. Candidates may also provide a bibliography, if appropriate. Each piece of continuously assessed work should contain between 3000 and 4000 words, unless stated otherwise, supported with diagrams and figures and including a detailed analysis. It is an essential requirement that the analysis and its results are presented in an academically rigorous manner. The 4 pieces of continuously assessed work must be aligned with the co-requisites of `Railway Systems Synthesis C' and must be related to railway systems engineering and integration.

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**Module Title:** Railway Strategy, Safety and Control Systems

**Module Code:** 34740

**Semester:** 1

**Credits:** 20

**Level:** LM

**Module Description:** This module provides the strategic background, understanding and tools the railway system and the associated planning functions. It allows students to develop a solid understanding of the constraints and opportunities applicable to railway systems, including the politics of ownership, funding sources, strategic safety management, regulation signalling and operations and some of the railway and professional functions that support them. The module also covers the governmental, financial, and societal contexts that influence railway safety, operations and planning. The module is delivered through case studies, interactive lectures, and team activities to develop the knowhow and knowledge required to operate railways of all types. The teaching is supported by a wide variety of senior guest lecturers from the railway sector.

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**Module Title:** Rolling Stock and Infrastructure Systems

**Module Code:** 26310

**Semester:** 2

**Credits:** 10

**Level:** LM

**Module Description:** The infrastructure portion of this module is designed to give students an in-depth technical knowledge of the rolling stock and infrastructure systems and an understanding of how to design and maintain them in order to minimise risk and maximise safety. Railway alignment design, gauging, and maintenance issues are discussed in detail, as are issues relating to the rolling contact behaviour of the wheel-rail interface and to rail vehicle dynamics, including the steering of wheelsets.

Aerodynamics, body-shell design and crashworthiness issues, choice of materials, vehicle maintenance, and the design and behaviour suspensions are covered in some detail. Also addressed are the topics of station design, station systems and infrastructure power supply components. The module is managed by the Department of Civil Engineering of the University of Birmingham, with inputs and guest speakers from the railway industry.

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**Module Title:** Principles of Railway Control Systems

**Module Code:** 31216

**Semester:** 1

**Credits:** 20

**Level:** LM

**Module Description:** Students will gain detailed knowledge and understanding of the principles of operation of railway signalling and control systems. This will relate to various jurisdictions around the world, focussing on the UK, Europe plus selected detail relevant to students’ home countries. They will understand and be able to analyse the complex interactions between system components; health and safety requirements; tools and techniques for system design and for problem-solving. Attendance at regional professional institution seminars will be expected and will bring relevance and application to students’ learning. This module will equip students to apply railway signalling, control and communications systems into Industrial settings whilst taking into consideration safety, risk management, systems engineering, cost-effectiveness, choice of components, testing strategies, maintainability and reliability.

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**Module Title:** Applications of Railway Control Systems

**Module Code:** 31215

**Semester:** 2

**Credits:** 20

**Level:** LM

**Module Description:** Students will undertake a module-project to apply railway signalling and control systems relevant to a selected jurisdiction e.g. the UK, Europe or the student’s home country. Students will design or work with an existing design, as appropriate to the setting, of a railway signalling and control system. Typical activities will include performing relevant calculations, reflecting on the impact of systems engineering, and applying problem-solving tools and techniques. All projects will include elements of Health & Safety, reliability, availability, maintainability, environmental matters and cost-effectiveness.

Students will complete an inception report within the first 3 weeks which outlines their overall project focus. An interim report half-way through the project will provide structure to the final report and allows for supervision feedback to be formalised.

Projects will be sought from Industrial supporters of the study programme to bring additional relevance to real-world issues. Students studying on part-time and distance-learning modes will be expected to complete this module in the workplace. Full-time students will undertake the module after having completed Principles of Railway Control Systems, and in conjunction with industrial supporters.

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# Integrated Design Projects

**Module Title:** Integrated Design Project 2

**Module Code:** 29652

**Semester:** 2

**Credits:** 20

**Level:** LI

**Module Description:** This module provides students with the opportunity to take on, as part of a team, real life conceptual design challenges. The project design aspects of the work will aim at enhancing students’ awareness regarding challenges imposed by key issues such as globalisation, climate change, sustainability and inequality, and the way these impact their role as Engineers, working in teams.

Teams will be drawn from Civil Engineering, Mechanical Engineering and EESE cohorts, working together in cross-disciplinary teams to provide design solutions to real world project scenarios. The project team will divide into discipline specific tasks required to meet the global design challenge, with discipline specific activities feeding into the final integrated design.

This module will be supported by a series of taught sessions run over semesters 1 and 2 to provide support at key stages of project work. These will target key requirements to deliver successful integrated projects designs. These sessions will include:

1. The systems engineering approach and design philosophy
2. Project Planning, management and effective team working
3. Health and Safety aspects and impact on design
4. Sustainability aspects of design, including stakeholder engagement; ethics; human factors
5. Why projects fail: nature of risk in working/business operations; risk management
6. Key presentation skills: including drawing/sketching, report writing; presentation and Q&A.

These will be supplemented by discipline specific taught sessions covering key material in support of discipline activities.

1. Civil Engineering: Structural design and analysis including indeterminate structures; moment distribution; substitute frames; construction and workmanship aspects, introduction to forensic engineering in Civil Engineering
2. EESE: Software development for design and automation
3. Mechanical Engineering: mechanical power transmission systems.

Teams will ultimately produce final design concepts that demonstrate full integration of discipline led tasks.

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**Module Title:** Integrated Design Project 3 (BEng)

**Module Code:** 29646

**Semester:** 2

**Credits:** 20

**Level:** LH

**Module Description:** This module provides students with the opportunity to take on, as part of a team, real life designs challenges that address world-wide problems, providing an opportunity to apply cross-disciplinary working to solve a range of different problems. There will also be team projects based around the Formula Student Project.

The project design aspects of the work will aim at enhancing students’ awareness regarding challenges imposed by key issues such as globalisation, climate change, sustainability and inequality, and the way these impact their role as Engineers, working in teams.

Groups will be drawn from Civil Engineering, Mechanical Engineering and EESE cohorts, working together in cross-disciplinary teams to provide design solutions to real world project scenarios. The team will divide into discipline specific design project groups required to meet a global design challenge, with discipline specific activities feeding into the final integrated solution.

Teams will ultimately produce final design concepts that demonstrate full integration between discipline led tasks.

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**Module Title:** Integrated Design Project 3 (MEng)

**Module Code:** 29658

**Semester:** 2

**Credits:** 20

**Level:** LH

**Module Description:** This module provides students with the opportunity to take on, as part of a team, real life designs challenges that address world-wide problems, providing an opportunity to apply cross-disciplinary working to solve a range of different problems. There will also be team projects based around the Formula Student Project.

The project design aspects of the work will aim at enhancing students’ awareness regarding challenges imposed by key issues such as globalisation, climate change, sustainability and inequality, and the way these impact their role as Engineers, working in teams.

Groups will be drawn from Civil Engineering, Mechanical Engineering and EESE cohorts, working together in cross-disciplinary teams to provide design solutions to real world project scenarios. The team will divide into discipline specific design project groups required to meet the a global design challenge, with discipline specific activities feeding into the final integrated solution.

Teams will ultimately produce final design concepts that demonstrate full integration between discipline led tasks.

Student will produce a final prototype/product as part of their final submissions.

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