THE DYSON INSTITUTE

Module Information for 2021

Year three

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Module information	
Year 3	
Name of module	**Acoustics**
Module description	Sound impacts on our daily lives in many ways, from the safety and comfort of the environments in which we live and work, to the functionality of the products that we use. The aim of this module is to understand the origins of sound, how we perceive it, and the subsequent implications for product design. The module will cover the underlying physics of sound and sound propagation, introducing the one-dimensional wave equation; along with time- and frequency-domain representations of sound signals. Approaches for the measurement and analysis of sound will be introduced and discussed. Participants will learn about controlling noise, with an overview of noise legislation and its application to products and the environment.
Outline Syllabus	• Introduction to sound • Sound propagation • One-dimensional wave equation • Source power and intensity • Time and frequency domain representations • Sinusoidal signals and noise spectra • Sound perception • Measuring sound • Acoustic impedance and absorption • Reflection and diffraction • Noise legislation • Wave motion through ducts • Noise control methods
Method of assessment and weighting attributed to each area of assessment	40% Unseen Examination 45% Group Report 15% Group Presentation

Name of module	Manufacturing and Metrology
Module description	The aim of this module is to understand and appreciate appropriate manufacturing technologies as well as the role of metrology in an advanced production environment. A comprehensive knowledge of the modern manufacturing techniques is of vital importance for a number of engineering disciplines including Mechanical, Industrial, Manufacturing etc. The module will cover a range of conventional and non-conventional manufacturing. In this module participants will examine how advanced manufacturing organisations make extensive use of computers and information technologies and high precision specialist manufacturing technology to produce a heterogeneous mix of products in small or large volumes with both the efficiency of mass production and the flexibility of custom manufacturing in order to respond quickly to customer demands. Metrology, being an integral part of manufacturing, is directly related to quality and conformity of the final product. With modern design tools and techniques, it is possible to define products and develop their virtual model, and fully validate by simulation methods. The journey from virtual design to real word cannot be fulfilled without a good understanding of the design feasibility in terms of dimensioning and tolerance definition linked with available manufacturing capabilities. This module reviews the context of metrology and manufacturing methods and their limitations for designers. The concept of uncertainty in design and product maturation are explained. Measurement technologies, their applications, related standards, and best practices are reviewed.
Outline Syllabus	• Conventional and Computerised Numerically Controlled (CNC) machine tools: turning, milling, drilling etc, • Cutting tool technology- materials, geometry, surface coatings, constraint, working conditions etc • Non-conventional processing: Laser, EDM, Water Jet, Ultrasonic etc • Rapid prototyping techniques for polymers and metals (e.g. Additive Manufacturing, 3D printing etc) • Composite component construction for high performance and volume application • Sheet metal forming using conventional and specialist techniques such as hydroforming and superplastic forming. • Metrology, manufacturing, and variation • Terminology and standards • Statistical process control (SPC) • Principles and methods of measurement • Coordinate measurement methods

	• Measurement uncertainty • Measurement systems analysis
Method of assessment and weighting attributed to each area of assessment	40% Unseen Examination 45% Group Report 15% Group Presentation

Name of module	Advanced Fluid Dynamics
Module description	This module starts with introduction and derivation of fundamental conservation laws for fluids (mass, momentum, and energy), and demonstrate the application of these equations for solving simple flow problems. This will be expanded further by focusing on classical theory of fluid dynamics by covering viscous flows with emphasis on boundary layers, potential flows, turbomachinery fluid dynamics, and compressible flows.
Outline Syllabus	• Refresher on year 2 fluids: flow properties; fluid as continuum, Langragian and Eulerian description, velocity and stress field, fluid statics/kinematics; … • Reynolds transport theorem, integral and differential forms of governing equations: mass, momentum and energy conservation equations, Navier-Stokes equations, Euler's equation, Bernoulli's Equation. • Boundary layer equations, boundary layer thickness, boundary layer on a flat plate, similarity solutions, integral form of boundary layer equations, flow separation, inviscid stability theory, boundary layer stability, transition to turbulence. • Stream and velocity potential function, circulation, irrotational vortex, basic plane potential flows: uniform stream, source and sink, vortex flow, doublet, superposition of basic plane potential flows. • Flow past a circular cylinder, Magnus effect, Kutta-Joukowski lift theorem, concept of lift and drag. • Turbomachinery; introduction, elementary pump theory, centrifugal/axial-flow pumps, turbines, specific speed in pumps and turbines, estimation of the critical speeds • Principles of compressible flow; compressible flow through nozzles, diffusers and wind tunnels. • Quasi-one-dimensional flows, compressible viscous flows, compressible boundary layers. • Speed of sound and Mach number, basic equations for one dimensional flows, isentropic relations, con-di nozzle, normal-shock wave. • Rankine-Hugoniot relations, Fanno and Rayleigh curve, Mach waves, oblique shock wave, Prandtl-Meyer expansion waves.
Method of assessment and weighting attributed to each area of assessment	40% Unseen Examination 45% Group Report 15% Group Presentation

Name of module	Advanced Heat Transfer and Thermodynamics
Module description	In the first part of this module the theories and applications of heat transfer as well as mass transfer will be introduced, and students will be equipped with the knowledge and skills required to solve problems for the design, assessment, and analysis of heat and mass transfer processes. In the second part, the module will aim to develop the abilities to understand, model and analyse advanced thermodynamics theories and systems and apply these to engineering systems. The advanced thermodynamic cycles component will include the analysis of real power heating and cooling systems using thermodynamic principles.
Outline Syllabus	Heat transfer • Fundamentals: revision of year 2 heat transfer concepts • Fin cooling; fin array; fin cooling with natural convection • Mass transfer: mass diffusion; heat & mass transfer; convective mass transfer; drying • Heat & mass transfer in porous media; filtration Thermodynamics • Gases: ideal gas; gas mixture; real gas behaviour, kinetic theory • Humidity: specific and relative humidity; saturation pressure; dew point; … • Real air cycles: polytropic eq. of state; Otto cycle; Diesel cycle • Refrigeration: P-h and T-S diagram; reversed Carnot cycle; cryogenics • Heat pumps: applications; coefficient of performance, • Solid state heat pumps: thermoelectric materials/cooling
Method of assessment and weighting attributed to each area of assessment	40% Unseen Examination 45% Group Report 15% Group Presentation

Name of module	Embedded Systems
Module description	The module will present the fundamentals of embedded systems including the microcontrollers' architecture, programming languages, combinational logic and practical examples to show the trade-offs between power, performance and cost. A state-of-the-art microcontroller development suite will be used to analyse various aspects of embedded systems' hardware as well as the conversion between analogue and digital signals given the application of sensors/actuators in an industrial context.
Outline Syllabus	• The history and architecture of embedded systems • Programming languages and development tools (C/C++) • Compilation, assembly and linking in the translation process • General purpose input/output and writing set of operations for them • Asynchronous and synchronous serial communication • Data formatting, timing diagrams, and signalling levels • Perform voltage to binary and binary to voltage numerical conversions • Embedded designing and programming for monitoring physical properties • Embedded designing and programming for effecting physical control • Interrupts, waveform generation and time measurement • Applications of pulse width modulation • I/O buses and master/slave devices • Wireless ports (Wireless updates, bootloaders, functionality of products) • Event-driven and real-time solutions • Low Power Modes, Power Budgeting • Safety requirements
Method of assessment and weighting attributed to each area of assessment	40% Unseen Examination 45% Group Report 15% Group Presentation

Name of module	Systems Modelling and Control
Module description	Most disciplines of the engineering profession require a sound understanding of the techniques used in the modelling and control of dynamic, multi-domain physical, and other, systems. The aims of this module are to introduce techniques and computer tools for modelling, predicting and analysing the behaviour of dynamic systems; and to introduce concepts, principles and techniques employed in classical methods of single loop feedback control design.
Outline Syllabus	• Systems modelling and control in state space • Non-linear systems, equilibrium points and linearization • Linear time invariant (LTI) systems • Transfer Matrix, Controllability, Observability, and Reachability • Multiple-Input Multiple-Output (MIMO) Systems • Root Locus analysis and controller design • Digital control • Z-transform • Digital PID • Digital controller design • Practical Applications and Implementation • Simscape • Hardware in the Loop • Design Cycle (Design and virtual testing)
Method of assessment and weighting attributed to each area of assessment	40% Unseen Examination 45% Group Report 15% Group Presentation

Name of module	Analogue Systems
Module description	The module aims to provide students with the ability to analyse and design analogue electronic circuits. They will be able to use Electronic Design Automation tools, for different simulation analyses. It will encompass typical functions of analogue circuits: voltage and current references, operational amplifiers (internal topology and their utilisation in different closed-loop circuits), filters, signal conditioning, comparators, oscillators and signal generators. Students will be encouraged to explore and compare the performance of different circuits with the same functionality.
Outline Syllabus	• Analogue circuit modelling and simulation • Behaviour of discrete components • Class AB and B power amplifiers • Voltage and current references • Operational amplifiers (including internal topology) • Analogue multipliers and their applications • Operational transconductance amplifiers and applications • Design of analogue filters • Signal selection, processing and conversion (including multiplexing, ADCs and DACs) • Comparators, hysteresis • Oscillators and voltage-controlled oscillators • Waveform generators • Sensitivity and Tolerance • Worst case design analysis
Method of assessment and weighting attributed to each area of assessment	40% Unseen Exam 45% Individual Report 15% Demonstration

Name of module	Energy Storage Systems
Module description	Renewable energies such as wind power, solar power, geothermal energy, hydropower or bio-energy have the potential to deliver sustainable energy on windy and sunny days or as base-load grid energy, respectively. Energy storage is needed to enable transition towards energy systems with low environmental impact. This course is designed for introducing different renewable technologies and a deeper understanding of the underlying concepts and processes of energy storage. The module will provide students with a firm grounding in the thermodynamic principles of electrochemical, electrical and mechanical energy conversion with a deeper focus on fuel cells and energy storage methods, e.g., batteries, supercapacitors, by targeting technological aspects as well as simulation strategies.
Outline Syllabus	Introduction to Energy Storage • General background on alternative energy sources and sustainability • Resource scale and availability • Available technologies, implications and challenges Batteries • Principle of operation • Battery components (electrode, cell, modules and packs) • Governing physics (coupled electrochemical and thermal) • Battery Thermal Management Fuel Cells and Hydrogen Storage • Types of fuel cells • Physics of PEM fuel cells and its modelling • Hydrogen storage systems Supercapacitors • Aqueous and organic based supercapacitors • Pseudo and asymmetric supercapacitors System Integration • Applications • Product development Hybrid Systems • Mechanical storage (Wider Electrical System), Hydroelectric, etc.
Method of assessment and weighting attributed to each area of assessment	40% Unseen Exam 45% Individual Report 15% Individual Presentation

Name of module	Power Electronics
Module description	Modern electronic equipment, domestic and industrial alike, requires conditioning of the electric supply delivered to it in order to enable adequate, efficient and flexible operation. The electronics is used for processing power rather than information. This module aims to introduce the concept of power electronic devices and their usage for power processing, conversion, and control purposes. It will present the range of applications of power electronics, from power supplies for laptops to motor drives in appliances, robotics and electric vehicles.
Outline Syllabus	• Detailed characteristics of power devices – diodes, IGBTs, MOSFETs, thyristors • Limitations in utilisation – voltages, currents, switching frequencies • Power converters: AC-DC converters, DC-DC converters, isolated converters, bridges and 3-phase inverters, resonant converters • Non-ideal cases, commutation and overlap, dead time in inverters • Introduction of power quality and filters. • Grounding and user safety issues regarding electric shock and excessive temperatures. • Pulse-width modulation in converters • Design and simulation of converters • Applications (e.g. laptop charger design, solar power, wind power, hybrid & electric vehicles) • Charge and discharge of Power Electronic Converters (Energy Storage Systems) • Safety
Method of assessment and weighting attributed to each area of assessment	40% Unseen Exam (2 hours) 45% Individual Report (3000 words) 15% Individual Presentation (10 minutes)

Name of module	Big Data Analytics
Module description	This module will aim to introduce students to the concepts, terminologies and algorithms for big data analytics. Starting with methods for collecting data, students will then learn tools and techniques for cleaning data and dealing with inconsistent, missing and redundant data. Methods for analysing structured and unstructured data are then presented.
Outline syllabus	Fundamentals of big data Statistical background Collecting and categorising data Cleaning and transforming data Analysing data and data mining Making use of big data Technologies for big data
Method of assessment and weighting attributed to each area of assessment	45 % - Assignment 15 % - Assignment demonstration/presentation 40 % - Examination

Name of module	Signal Processing
Module description	Digital Signal Processing can analyse, modify and enhance various signals; audio, video and communication signals. It supports and enhances interfaces between humans, between machines and between humans and machines. This module provides a detailed knowledge base for the theoretical and practical techniques used in discrete-time systems. It aims to develop the students' skills in designing digital filters and using Fourier transform techniques. Several digital image processing techniques will be introduced and then used in simulations and practical laboratory sessions.
Outline syllabus	Linear time Invariant Systems • Continuous and Discrete time signals • Introduction to linear time invariant systems • Properties of Linear Time-Invariant (LTI) systems • Shift invariance, stability and causality • Impulse response and difference equations Discrete Fourier transform • Transform definitions and its properties • Fourier Transform of LTI system • Inverse Fourier transform Z-Transform • Transform definition and its properties • Regions of convergence • Inverse Z transform • Relation of Discrete Fourier Transform with Z-transform Sampling and reconstruction • Linear and cyclic convolution • Sampling and reconstruction of continuous-time signals • Aliasing and re-sampling digital signals Digital Filters • Properties of digital filters • Digital filter design techniques • Window designing techniques for finite impulse response filters • Bilinear transform method for designing infinite impulse response filters • Structural properties of FIR and IIR filters Fast Fourier Transform • Decimation in time using Fast Fourier Transform • Decimation in frequency using Fast Fourier Transform • Introduction to image processing techniques
Method of assessment and weighting attributed to each area of assessment	45 % - Assignment 15 % - Assignment demonstration 40 % - Examination

Name of module	Software Development Lifecycle
Module description	The module aims to present software development principles and good practices. The module covers the main phases of software development life cycle including requirements analysis, design, development, testing and maintenance. A brief introduction to tools and techniques for managing changes in software, code and documentation will also be discussed in the module. The module will also cover the important factors relating to software quality including functionality, reliability, usability, portability and maintainability.
Outline syllabus	• Importance of Software Engineering • Software development methodologies • Stages of software development life cycle • Gathering and analysing requirements • Software Design using UML • Designing the Software using UML • Use Case diagram • Activity diagram • Sequence diagram • State diagram • Deployment diagram • Gang of Four design patterns • Object-oriented software design • Test-driven development • Software testing • Blackbox testing • Whitebox testing • Overview of software quality assurance • Program verification technologies and methods • Inspections and code reviews • Software configuration control • Implementing software changes • Software documentation
Method of assessment and weighting attributed to each area of assessment	45 % - Assignment 15 % - Assignment demonstration/presentation 40 % - Examination

Name of module	Systems and Network Architecture
Module description	This module aims to equip students with the knowledge of computer architecture and networked computer systems required to build a small to medium-networked computer and the corresponding switching routing principles. This includes topics such as IP addressing techniques (IPv4 and IPv6); command-line interface (CLI) configuration of Ethernet switches, routers, Virtual Local Area Networks (VLANs); network security and firewalls. Software based real-world scenarios are used to enhance the theoretical knowledge of network devices and configure both Ethernet switching and IP configuration. Automotive communication network protocols such as Flex Ray, CAN and LIN will also be covered in this module. Skills acquired in this module will enable students to identify, plan, build and maintain computer systems networks, as well as troubleshoot common hardware and software problems in an industrial environment.
Outline syllabus	• Computer architecture and internetworking - computer architecture; control units including hardwired and microprogrammed control units; performance of microprocessors; RISC/CISC architectures and the Central Processing Unit (CPU). Storage devices, memory hierarchy, data storage and elementary error detection and correction. Brief number system reminder and binary/decimal conversion for networking. Basics of internetworking, background of data communication (wired, wireless). Network topologies (Star, Mesh, Hybrid) and core/access tiers. Cabling technology, troubleshoot interface and cable issues; Network Interface Card • The OSI Reference Model, TCP/IP reference model - Error-detection and correction techniques; Principles of Reliable Data Transfer. Network Devices: Hub, Switch, Router, Firewalls, Access points, Wireless controllers and their role in connection with the TCP/IP model • Ethernet technology - Multiple Access Links and Protocols (static and dynamic channel allocation). MAC addressing, Frame format Broadcast & collusion domain. Describe and verify switching concepts (MAC learning, Frame switching, frame flooding, MAC address table); Further protocol discussions such as STP algorithm • IP addressing and routing - Network Protocols, IPv4 address types (Unicast, Multicast, and Broadcast); IPv6 basics. Private and Public networks. Subnet Mask troubleshoot IPv4 addressing and sub-netting. Introducing the most common services such as HTTP, DNS and Email and VOIP and corresponding layers

	• Advanced features - Automotive Networks characteristics and its communication requirements. The combined wired/wireless network infrastructure modes. Steps for designing and configuring a combined network. Security aspects and configurations in a simple personal or a network-based enterprise architecture
Method of assessment and weighting attributed to each area of assessment	45 % - Assignment 15 % - Assignment demonstration/presentation 40 % - Examination