# PEARSON BTEC LEVEL 5 HND DIPLOMA IN ENGINEERING (ELECTRICAL AND ELECTRONIC ENGINEERING) (RQF)

## MODULE SYNOPSIS

| ENGINEERING DESIGN |
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| The tremendous possibilities of the techniques and processes developed by engineers can only be realised by great design. Design turns an idea into a useful artefact, the problem into a solution, or something ugly and inefficient into an elegant, desirable and cost effective everyday object. Without a sound understanding of the design process the engineer works in isolation without the links between theory and the needs of the end user.<br>The aim of this unit is to introduce students to the methodical steps that engineers use in creating functional products and processes; from a design brief to the work, and the stages involved in identifying and justifying a solution to a given engineering need.<br><br>Among the topics included in this unit are: Gantt charts and critical path analysis, stakeholder requirements, market analysis, design process management, modeling and prototyping, manufacturability, reliability life cycle, safety and risk, management, calculations, drawings and concepts and ergonomics.<br>On successful completion of this unit students will be able to prepare an engineering design specification that satisfies stakeholders' requirements, implement best practice when analyzing and evaluating possible design solutions, prepare a written technical design report, and present their finalized design to a customer or audience. |

## UNIT CONTENT

**LO1 Prepare an engineering design specification in response to a stakeholder's design brief and requirements**

*Planning techniques used to prepare a design specification:*
Definition of client's/users objectives, needs and constraints. Definition of design constraints, function, specification, milestones.
Planning the design task: Flow charts, Gantt charts, network and critical path analysis necessary in the design process.

*Design process:*
Process development, steps to consider from start to finish. The cycle from design to manufacture. Three- and five-stage design process. Vocabulary used in engineering design.

*Stage of the design process which includes:*
Analysing the situation, problem statement, define tasks and outputs, create the design concept, research the problem and write a specification. Suggest possible solutions, select a preferred solution, prepare working drawings, construct a prototype, test and evaluate the design against objectives, design communication (write a report).

*Customer/stakeholder requirements:*
Converting customer request to a list of objectives and constraints. Interpretation of design requirements. Market analysis of existing products and competitors. Aspects of innovation and performance management in decision-making.

**LO2 Formulate possible technical solutions by using prepared examples of engineering design specifications**

*Conceptual design and evaluating possible solutions:*
Modelling, prototyping and simulation using industry standard software, (e.g.AutoCAD, Catia, SolidWorks, Creo) on high specification computers. Use of evaluation and analytical tools, e.g. cause and effect diagrams, CAD,knowledge-based engineering.

**LO3 Prepare an engineering industry standard technical design report by using appropriate design calculations, drawings and concepts**

*Managing the design process:*
Recognising limitations including cost, physical processes, availability of material/components and skills, timing and scheduling.

*Working to specifications and standards, including:*
The role of compliance checking, feasibility assessment and commercial viability of product design through testing and validation.

*Design for testing, including:*
Material selection to suit selected processes and technologies. Consideration of manufacturability, reliability, life cycle and environmental issues. The importance of safety, risk management and ergonomics.

*Conceptual design and effective tools:*
Technologies and manufacturing processes used in order to transfer engineering designs into finished products.

**LO4 Present, to an audience, a recommended technical design solution by using real examples of stakeholder briefs**

*Communication and post-presentation review:*
Selection of presentation tools. Analysis of presentation feedback. Strategies for improvement based on feedback.

## ENGINEERING MATHS

The mathematics that is delivered in this unit is that which is directly applicable to the engineering industry, and it will help to increase students' knowledge of the broad underlying principles within this discipline.

The aim of this unit is to develop students' skills in the mathematical principles and theories that underpin the engineering curriculum. Students will be introduced to mathematical methods and statistical techniques in order to analyse and solve problems within an engineering context.
On successful completion of this unit students will be able to employ mathematical methods within a variety of contextualised examples, interpret data using statistical techniques, and use analytical and computational methods to evaluate and solve engineering problems.

## UNIT CONTENT

**LO1 Identify the relevance of mathematical methods to a variety of conceptualised engineering examples**

*Mathematical concepts:*
Dimensional analysis. Arithmetic and geometric progressions.

*Functions:*
Exponential, logarithmic, circular and hyperbolic functions

**LO2 Investigate applications of statistical techniques to interpret, organise and present data, by using appropriate computer software packages**

*Summary of data:*
Mean and standard deviation of grouped data. Pearson's correlation coefficient. Linear regression.

*Probability theory:*
Binomial and normal distribution.

**LO3 Use analytical and computational methods for solving problems by relating sinusoidal wave and vector functions to their respective engineering applications.**

*Sinusoidal waves:*
Sine waves and their applications. Trigonometric and hyperbolic identities.

*Vector functions:*
Vector notation and properties. Representing quantities in vector form. Vectors in three dimensions.

**LO4 Illustrate the wide-ranging uses of calculus within different engineering disciplines by solving problems of differential and integral calculus**

*Differential calculus:*
Differentiation of functions.

*Stationary points:*
Rates of change.

*Integral calculus:*
Definite and indefinite integration. Integrating to determine area and common functions. Integration by substitution. Exponential growth and decay.

# ENGINEERING SCIENCE

Engineering is a discipline that uses scientific theory to design, develop or maintain structures, machines, systems, and processes. Engineers are therefore required to have a broad knowledge of the science that is applicable to the industry around them.

This unit introduces students to the fundamental laws and applications of the physical sciences within engineering and how to apply this knowledge to find solutions to a variety of engineering problems.
Among the topics included in this unit are: international system of units, interpreting data, static and dynamic forces, fluid mechanics and thermodynamics, material properties and failure, and A.C./D.C. circuit theories.

On successful completion of this unit students will be able to interpret and present qualitative and quantitative data using computer software, calculate unknown parameters within mechanical systems, explain a variety of material properties and use electromagnetic theory in an applied context.

## UNIT CONTENT

**LO1 Examine scientific data using computational methods**

*International system of units:*
The basic dimensions in the physical world and the corresponding SI base units. SI derived units with special names and symbols.SI prefixes and their representation with engineering notation.

*Interpreting data:*
Investigation using the scientific method to gather appropriate data. Summarizing quantitative and qualitative data with appropriate graphical representations. Using presentation software to present data to an audience.

**LO2 Determine parameters within mechanical engineering systems**

*Static and dynamic forces:*
Representing loaded components with space and free body diagrams. Calculating support reactions of objects subjected to concentrated and distributed loads. Newton's laws of motion, D'Alembert's principle and the principle of conservation of energy.

*Fluid mechanics and thermodynamics:*
Archimedes' principle and hydrostatics. Continuity of volume and mass flow for an incompressible fluid. Heat transfer due to temperature change and the thermodynamic process equations

**LO3 Explore the characteristics and properties of engineering materials**

*Material properties:*
Atomic structure of materials and the structure of metals, plastics and composites. Mechanical and electromagnetic properties of materials.

*Material failure:*
Destructive and non-destructive testing of materials. The effects of gradual and impact loading on a material. Degradation of materials and hysteresis.

**LO4 Analyse applications of electromagnetic principles and properties**

*D.C. circuit theory:*
Voltage, current and resistance in D.C. networks. Exploring Ohm's law and Kirchhoff's voltage and current laws.

*A.C. circuit theory:*
Waveform characteristics in a single-phase A.C. circuit.RLC circuits.

*Magnetism:*
Characteristics of magnetic fields and electromagnetic force. The principles and applications of electromagnetic induction.

## MANAGING A PROFESSIONAL ENGINEERING PROJECT

This unit introduces students to the techniques and best practices required to successfully create and manage an engineering project designed to identify a solution to an engineering need. While carrying out this project student will consider the role and function of engineering in our society, the professional duties and responsibilities expected of engineers together with the behaviours that accompany their actions.

Among the topics covered in this unit are: roles, responsibilities and behaviours of a professional engineer, planning a project, project management stages, devising solutions, theories and calculations, management using a Gantt chart, evaluation techniques, communication skills, and the creation and presentation of a project report.
On successful completion of this unit students will be able to conceive, plan, develop and execute a successful engineering project, and produce and present a project report outlining and reflecting on the outcomes of each of the project processes and stages. As a result, they will develop skills such as critical thinking, analysis, reasoning, interpretation, decision-making, information literacy, and information and communication technology, and skills in professional and confident self-presentation.

## UNIT CONTENT

**LO1 Formulate and plan a project that will provide a solution to an identified engineering problem, with reference to national and international engineering regulatory regimes, and ethical frameworks**

*Examples of realistic engineering based problems:*
Crucial considerations for the project. How to identify the nature of the problem through vigorous research. Feasibility study to identify constraints and produce an outline specification.

*Develop an outline project brief and design specification:*
Knowledge theories, calculations and other relevant information that can support the development of a potential solution.

*Ethical frameworks:*
The Engineering Council and Royal Academy of Engineering's Statement of Ethical Principles
The National Society for Professional Engineers' Code of Ethics

*Regulatory bodies:*
Global, European and national influences on engineering and the role of the engineer, in particular: The Royal Academy of Engineering and the UK Engineering Council. The role and responsibilities of the UK Engineering Council and the Professional Engineering Institutions (PEIs). The content of the UK Standard for Professional Engineering Competence (UKSPEC). Chartered Engineer, Incorporated Engineer and Engineering Technician.

*International regulatory regimes and agreements associated with professional engineering:*

European Federation of International Engineering Institutions. European Engineer (Eur Eng).
European Network for Accreditation of Engineering Education. European Society for Engineering Education. Washington Accord. Dublin Accord. Sydney Accord. International Engineers Alliance. Asia Pacific Economic Cooperation (APEC) Engineers Agreement.

**LO2 Conduct planned project activities to generate outcomes which provide a solution to the identified engineering problem, with reference to ethical frameworks, health and safety requirements and professional standards of behaviour in engineering**

*Project execution phase:*
Continually monitoring development against the agreed project plan and adapt the project plan where appropriate. Work plan and time management, using Gantt chart or similar. Tracking costs and timescales. Maintaining a project diary to monitor progress against milestones and timescales.

*Engineering professional behaviour sources:*
Professional responsibility for health and safety (UK-SPEC). Professional standards of behaviour (UK-SPEC).

*Ethical frameworks:*
The Engineering Council and Royal Academy of Engineering's Statement of Ethical Principles. The National Society for Professional Engineers' Code of Ethics.

**LO3 Produce a project report analysing the outcomes of each of the project processes and stages**

*Convincing arguments:*

All findings/outcomes should be convincing and presented logically where the assumption is that the audience has little or no knowledge of the project process.

*Critical analysis and evaluation techniques:*
Most appropriate evaluation techniques to achieve a potential solution. Secondary and primary data should be critiqued and considered with an objective mindset. Objectivity results in more robust evaluations where an analysis justifies a judgement.

**LO4 Present the project report and reflect on the value gained from conducting the project and potential improvements in future projects**

*Presentation considerations:*
Media selection, what to include in the presentation and what outcomes to expect from it. Audience expectations and contributions. Presentation specifics. Who to invite: project supervisors, fellow students and employers. Time allocation, structure of presentation. Reflection on project outcomes and audience reactions. Conclusion to report, recommendations for future work, lessons learned, changes to own work patterns.

*Reflection for learning and practice:*
The difference between reflecting on performance and evaluating a project – the former considers the research process, information gathering and data collection, the latter the quality of the research argument and use of evidence.

*The cycle of reflection:*
To include reflection in action and reflection on action. How to use reflection to inform future behaviour, particularly directed towards sustainable performance. The importance of Continuing Professional Development (CPD) in refining ongoing professional practice.

*Reflective writing:*
Avoiding generalisation and focusing on personal development and the research journey in a critical and objective way.

## ELECTRICAL AND ELECTRONIC PRINCIPLES

Electrical engineering is mainly concerned with the movement of energy and power in electrical form, and its generation and consumption. Electronics is mainly concerned with the manipulation of information, which may be acquired, stored, processed or transmitted in electrical form. Both depend on the same set of physical principles, though their applications differ widely. A study of electrical or electronic engineering depends very much on these underlying principles; these form the foundation for any qualification in the field, and are the basis of this unit. The physical principles themselves build initially from our understanding of the atom, the concept of electrical charge, electric fields, and the behaviour of the electron in different types of material.

This understanding is readily applied to electric circuits of different types, and the basic circuit laws and electrical components emerge. Another set of principles is built around semiconductor devices, which become the basis of modern electronics. An introduction to semiconductor theory leads to a survey of the key electronic components, primarily different types of diodes and transistors.
Electronics is very broadly divided into analogue and digital applications. The final section of the unit introduces the fundamentals of these, using simple applications. Thus, under analogue electronics, the amplifier and its characteristics are introduced. Under digital electronics, voltages are applied as logic values, and simple circuits made from logic gates are considered.

### UNIT CONTENT

**LO1 Apply an understanding of fundamental electrical quantities to analyse simple circuits with constant voltages and currents**

*Fundamental electrical quantities and concepts:*
Charge, current, electric field, energy in an electrical context, potential, potential difference, resistance, electromotive force, conductors and insulators.

*Circuit laws:*
Voltage sources, Ohm's law, resistors in series and parallel, the potential divider. Kirchhoff's and Thevenin's laws; superposition.

*Energy and power:*
Transfer into the circuit through, for example, battery, solar panel or generator, and out of the circuit as heat or mechanical. Maximum power transfer.

**LO2 Analyse simple circuits with sinusoidal voltages and currents**

*Fundamental quantities of periodic waveforms:*
Frequency, period, peak value, phase angle, waveforms, the importance of sinusoids.

*Mathematical techniques:*

Trigonometric representation of a sinusoid. Rotating phasors and the phasor diagram. Complex notation applied to represent magnitude and phase.

*Reactive components:*
Principles of the inductor and capacitor. Basic equations, emphasizing understanding of rates of change (of voltage with capacitor, current with inductor). Current and voltage phase relationships with steady sinusoidal quantities, representation on phasor diagram.

*Circuits with sinusoidal sources:*
Current and voltage in series and parallel RL, RC and RLC circuits. Frequency response and resonance.
Mains voltage single-phase systems. Power, root-mean-square power quantities, power factor.

*Ideal transformer and rectification:*
The ideal transformer, half-wave and full-wave rectification. Use of smoothing capacitor, ripple voltage.

**LO3 Describe the basis of semiconductor action, and its application to simple electronic devices**

*Semiconductor material:*
Characteristics of semiconductors; impact of doping, p-type and n-type semiconductor materials, the p-n junction in forward and reverse bias.

*Simple semiconductor devices:*
Characteristics and simple operation of junction diode, Zener diode, light emitting diode, bipolar transistor, Junction Field Effect Transistor (FET) and Metal Oxide Semiconductor FET (MOSFET). The bipolar transistor as switch and amplifier.

**LO4 Explain the difference between digital and analogue electronics, describing simple applications of each**

*Analogue concepts:*
Analogue quantities, examples of electrical representation of, for example, audio, temperature, speed, or acceleration. The voltage amplifier; gain, frequency response, input and output resistance, effect of source and load resistance (with source and amplifier output
modelled as Thevenin equivalent).

*Digital concepts:*
Logic circuits implemented with switches or relays. Use of voltages to represent logic 0 and 1, binary counting. Logic Gates (AND, OR, NAND, NOR) to create simple combinational logic
functions. Truth Tables.

## DIGITAL PRINCIPLES

The unit introduces the two main branches of digital electronics, combinational and sequential. Thus the student gains familiarity in the fundamental elements of digital circuits, notably different types of logic gates and bistables. The techniques by which such circuits are analysed are introduced and applied, including Truth Tables, Boolean Algebra, Karnaugh Maps, and Timing Diagrams.

The theory of digital electronics has little use unless the circuits can be built – at low cost, high circuit density, and in large quantity. Thus the key digital technologies are introduced. These include the conventional TTL (Transistor-Transistor Logic) and CMOS (Complementary Metal Oxide Semiconductor).

Importantly, the unit moves on to programmable logic, including the Field Programmable Gate Array (FPGA). Finally, some standard digital subsystems, which become important elements of major systems such as microprocessors, are introduced and evaluated.
On successful completion of this unit students will have a good grasp of the principles of digital electronic circuits, and will be able to proceed with confidence to further study.

### UNIT CONTENT

**LO1 Explain and analyse simple combinational logic circuits**

*Concepts of combinational logic:*
Simple logic circuits implemented with electro-mechanical switches and transistors. Circuits built from AND, OR, NAND, NOR, XOR gates to achieve logic functions, e.g. majority voting, simple logical controls, adders.

*Number systems, and binary arithmetic:*
Binary, Decimal, Hexadecimal number representation, converting between, applications and relative advantages.
Addition and subtraction in binary, range of *n*-bit numbers.

*Analysis of logic circuits:*
Truth Tables, Boolean Algebra, de Morgan’s theorem, Karnaugh Maps. Simplification and optimisation of circuits using these techniques.

**LO2 Explain and analyse simple sequential logic circuits**
Sequential logic elements and circuits: SR latch built from NAND or NOR gates. Clocked and edge-triggered bistables, D and JK types. Simple sequential circuits, including shift registers and counters.Timing Diagrams.

*Memory technologies:*
Memory terminology, overview of memory technologies including Static RAM, Dynamic RAM and Flash memory cells. Relative advantages in terms of density, volatility and power consumption. Typical applications, e.g. in memory stick, mobile phone, laptop.

**LO3 Describe and evaluate the technologies used to implement digital electronic circuits**

*Logic values represented by voltages:*
The benefit of digital representation of information. The concept of logic input and output values and thresholds.

*Digital technologies:*
Introduction to discrete logic families, CMOS and TTL, relative advantages in terms of speed, power consumption, density. Programmable logic, FPGAs, relative advantages and applications.

**LO4 Describe and analyse a range of digital subsystems, hence establishing the building blocks for larger systems**

*User interface:*
Examples to include switches, light emitting diodes and simple displays.
*Digital subsystems:*
Examples to be drawn from adders (half, full, *n*-bit), multiplexers and demultiplexers, coders and decoders, counters applied as timers, shift registers applied to serial data transmission, elements of the ALU (Arithmetic Logic Unit). Emphasis on how these can be applied, and how they might fit into a larger system.

## ELECTRICAL SYSTEMS AND FAULT FINDING

This unit introduces students to the characteristics and operational parameters of a range of electrical system components that are used in a variety of applications; and how to fault find when they go wrong.

On successful completion of this unit students will be able to follow electrical system circuit diagrams, understand the operation of the various components that make up the system and select the most suitable fault finding technique. Therefore, students will develop skills such as critical thinking, analysis, reasoning, interpretation, decision-making, information literacy, information and communication technology literacy, innovation, creativity, collaboration, and adaptability, which are crucial skills for gaining employment and developing academic competence for higher education progression.

### UNIT CONTENT

**LO1 Investigate the constructional features and applications of electrical distribution systems**

*Operating principles:*
Three-phase, single-phase distribution methods and connections. Earthing system connections.

*Transformer constructional features:*
Construction, application, characteristics of transformers such as step up/down, isolating, shell and core, windings, connections, efficiency. Electrical circuit symbols and layout diagrams.

*Fault finding techniques and test equipment:*
Input/output, half split. Meters, insulation testers. Typical faults found.

**LO2 Examine the types and applications of electrical motors and generators**

*Types and applications:*
Construction, application, characteristics, and testing. Types of electric motors and generators. Practical applications. Generation methods. Starting methods. Voltages, power, speed, torque, inertia. EMI, efficiency. Cooling and protection devices.

**LO3 Analyse the types of lighting circuits available in the industry by assessing their practical application**

*Types available and applications:*
Construction, application, characteristics and testing of lighting circuits. Types of lights available (high-intensity discharge lamps (HID lamps) such as metal-halide and sodium, fluorescent, light emitting diode (LED) and halogen). Practical applications. Voltages, energy usage, lumen output, efficiency, recycling. Safety requirements for use in hazardous zones.
Heat and protection devices.

*Lighting design:*

Quality of light, control of glare, luminance, internal/external lighting for visual tasks, emergency lighting, use in hazardous environments.

**LO4 Explain the operating characteristics of electrical safety components**

*Electrical safety standards:*
Approved codes of practice.

*Component types available and applications:*
Construction, application, characteristics and testing of: distribution boards, circuit breakers, residual current devices (RCDs), fuses, thermal devices, relays, contactors, switch gear, emergency stop buttons, interlocks, disconnectors, earth connections, Insulation Protection (IP) rating.

## ELECTRICAL MACHINES

Electrical machines can be found in manufacturing, transport, consumer appliances and hospitals. People will come across them every day in their home and at work. They convert energy in three ways: transformers which change the voltage level of an alternating current; motors which convert electrical energy to mechanical energy; and generators which convert mechanical energy to electrical energy. Transducers and actuators are also energy converters, and can be found in a wide range of industrial and domestic applications.

This unit introduces students to the characteristics and operational parameters of a range of electromagnetic powered machines that are used in a variety of applications. Among the topics included in this unit are: principles underlying the operation and construction of transformers, induction motors, synchronous machines, electromagnetic transducers, actuators, and generators; and operating characteristics of electrical machines such as voltage, current, speed of operation, power rating, electromagnetic interference (EMI) and efficiency.

On successful completion of this unit students will be able to identify the constructional features and applications of transformers; investigate the starting methods and applications of three-phase induction motors and synchronous machines; investigate the types of generator available in the industry by assessing their practical application; and analyse the operating characteristics of electromagnetic transducers and actuators.

### UNIT CONTENT

**LO1 Assess the constructional features and applications of transformers**

*Constructional features:*
Construction, application, characteristics and testing of transformer types such as: step up, step down, and isolating. Shell and core, windings, connections, efficiency, short circuit and no-load testing, and equivalent circuit.

**LO2 Analyse the starting methods and applications of the three-phase induction motors and synchronous machines**

*Methods and applications:*
Construction, application, characteristics and testing of induction and synchronous motors.
Types of electric motors and their practical applications. Starting methods. Voltages, power, speed, torque, inertia, EMI, and efficiency. Cooling and protection devices.

LO3 **Investigate the types of generators available in the industry by assessing their practical application**

*Types of generators available:*
Construction, application, characteristics and testing of generators. Types (direct current, alternating current and self-excitation).Practical applications. Generation methods.
Voltages, power, speed, torque, inertia, EMI, efficiency. Cooling and protection devices.

LO4 **Analyse the operating characteristics of electromagnetic transducers and actuators**

*Operating characteristics:*
Construction, application, characteristics and testing of electromagnetic transducers and actuators. Transducer types (active, passive, sensor), actuator types (solenoids, linear, rotary). Practical applications. Voltage and current requirements, hysteresis and speed of operation. Torque. Insulation Protection (IP) rating. Contact types. Back Electromotive Force (EMF), EMI and efficiency

## PROFESSIONAL ENGINEERING MANAGEMENT

Engineers are professionals who can design, develop, manufacture, construct, operate and maintain the physical infrastructure and content of the world we live in. They do this by using their academic knowledge and practical experience, in a safe, effective and sustainable manner, even when faced with a high degree of technical complexity.

The aim of this unit is to continue building up on the knowledge gained in *Managing a Professional Engineering Project*, to provide students with the professional standards for engineers and to guide them on how to develop the range of employability skills needed by professional engineers.

Among the topics included in this unit are: engineering strategy and services delivery planning, the role of sustainability, Total Quality Management (TQM), engineering management tools, managing people and becoming a professional engineer.

On successful completion of this unit students will be able to construct a coherent engineering services delivery plan to meet the requirements of a sector-specific organisation or business. They will display personal commitment to professional standards and obligations to society, the engineering profession and the environment.

## UNIT CONTENT

**LO1 Evaluate the risk evaluation theories and practices associated with the management of projects for the production of current and developing technology**

*The engineering business environment:*
Organizational structures and functional elements. Strategic planning and deployment. Engineering strategy and services delivery planning. The role of sustainability. Total Quality Management (TQM).Logistics and supply chain management. New product development strategies. Legal obligations and corporate responsibility.

*Engineering relationships:*
The relationship between engineering and financial management, marketing, purchasing, quality assurance and public relations.

**LO2 Produce an engineering services delivery plan that meets the requirements of a sector-specific organization**

*Engineering management tools:*
Problem analysis and decision-making, risk management, change management, performance management, product and process improvement, project management and earned value analysis.

**LO3 Develop effective leadership, individual and group communication skills**

*Managing people:*
Describe the most effective leadership styles. Techniques to effectively manage teams.
*Steps to follow for delivering effective presentations.*
Meeting management skills. Communication and listening skills. Negotiating skills. Human error evaluation. Coaching and mentoring.

**LO4 Develop personal commitment to professional standards and obligations to society, the engineering profession and the environment**

*Becoming a professional engineer:*
Engineering social responsibility. Importance of being active and up to date with the engineering profession, new developments and discoveries. Methods of Continuing Professional Development (CPD).

## FURTHER MATHEMATICS

The unit will prepare students to analyse and model engineering situations using mathematical techniques. Among the topics included in this unit are: number theory, complex numbers, matrix theory, linear equations, numerical integration, numerical differentiation, and graphical representations of curves for estimation within an engineering context. Finally, students will expand their knowledge of calculus to discover how to model and solve engineering problems using first and second order differential equations.

On successful completion of this unit students will be able to use applications of number theory in practical engineering situations, solve systems of linear equations relevant to engineering applications using matrix methods, approximate solutions of contextualised examples with graphical and numerical methods, and review models of engineering systems using ordinary differential equations.

## UNIT CONTENT

**LO1 Use applications of number theory in practical engineering situations**

*Number theory:*

Bases of a number (Denary, Binary, Octal, Duodecimal, Hexadecimal) and converting between bases.Types of numbers (Natural, Integer, Rational, Real, Complex). The modulus, argument and conjugate of complex numbers.Polar and exponential forms of complex numbers.The use of de Moivre's Theorem in engineering. Complex number applications e.g. electric circuit analysis, information and energy control systems.

**LO2 Solve systems of linear equations relevant to engineering applications using matrix methods**

*Matrix methods:*
Introduction to matrices and matrix notation. The process for addition, subtraction and multiplication of matrices. Introducing the determinant of a matrix and calculating the determinant for a 2x2 matrix. Using the inverse of a square matrix to solve linear equations.
Gaussian elimination to solve systems of linear equations (up to 3x3).

**LO3 Approximate solutions of contextualised examples with graphical and numerical methods**

*Graphical and numerical methods:*
Standard curves of common functions, including quadratic, cubic, logarithm and exponential curves.Systematic curve sketching knowing the equation of the curve.Using sketches to approximate solutions of equations.Numerical analysis using the bisection method and the Newton–Raphson method. Numerical integration using the mid-ordinate rule, the trapezium rule and Simpson's rule.

**LO4 Review models of engineering systems using ordinary differential equations**

*Differential equations:*
Formation and solutions of first-order differential equations. Applications of first-order differential equations e.g. RC and RL electric circuits, Newton's laws of cooling, charge and discharge of electrical capacitors and complex stresses and strains. Formation and solutions of second-order differential equations. Applications of second-order differential equations e.g. mass-spring-damper systems, information and energy control systems, heat transfer, automatic control systems and beam theory and RLC circuits. Introduction to Laplace transforms for solving linear ordinary differential equations. Applications involving Laplace transforms such as electric circuit theory, load frequency control, harmonic vibrations of beams, and engine governors.

## INDUSTRIAL POWER,ELECTRONICS AND STORAGE

This unit presents a wide-ranging introduction to the field of existing and renewable energy systems. There are many alternative sources of energy (some 'green')which can be converted to an electrical form, providing energy for transport, heat/cooling and lighting, as well as energy for various industrial processes and applications.

Power electronic converters are an essential component of renewable and distributed energy sources, including wind turbines, photovoltaics, marine energy systems and energy storage systems. It is necessary to gain a clear understanding of, and be able to examine, the technical implications of providing sustainable electrical energy to meet the energy demand of the future.
The unit will also explore the potential impacts of climate change and why more, and different forms of, sustainable energy sources are required together with the need for energy efficiency measures.
By the end of this unit students will be able to examine the technological concepts behind providing a sustainable electrical energy supply for the future. They will also be able to describe how the fundamental technical and economic processes and drivers at play in the electrical power industry affect the selection and use of energy sources.

## UNIT CONTENT

**LO1 Evaluate the energy demand to determine the technology and methods of energy production**

*Energy demand:*
Historical energy production, energy consumption, environmental aspects and global warming. The need for energy systems and global energy demand over the short to long term. Environmental effects associated with energy generation and consumption. Practicality, benefits, drawbacks and effectiveness of renewable energy sources. Overview of renewable energy technologies (wind, solar, bio, hydro, geothermal) and the associated costs. Future energy trends, scenarios and sustainable energy sources.

**LO2 Explore current energy efficiency measures, technologies and policies specific to the building and transportation sectors**

*Energy auditing, management, costs, requirements, bench marking and optimisation:*
Energy management, planning, monitoring, policy, ecology and environment.

*Energy and buildings:*
Overview of the significance of energy use and energy processes. Internal and external factors on energy use and the attributes of the factors. Status of energy use in buildings and estimation of energy use in a building. Standards for thermal performance of building envelope and evaluation of the overall thermal transfer. Measures and technologies to improve energy efficiency in buildings.

*Energy and electric vehicles:*
Electrical vehicle configurations, requirements, and circuit topology; electric and plug in hybrid vehicles. Policies, measures and technologies to support more sustainable transportation. Use of Matlab/Simulink or alternative appropriate software to model, simulate and analyse the energy efficiency of a typical standard house or electric vehicle.

**LO3 Analyse the control techniques of power electronics for renewable energy systems**

*Control techniques:*
Environmental aspects of electrical energy conversion using power electronics. Introduce design criteria of power converters for renewable energy applications. Analyse and comprehend the various operating modes of wind electrical generators and solar energy systems. Introduce the industrial application of power converters, namely AC to DC, DC to DC and AC to AC converters for renewable energy systems. Explain the recent advancements in power systems using the power electronic systems. Introduction to basic analysis and operation techniques on power electronic systems. Functional analysis of power converters' main topologies. Use of Matlab/Simulink to model, simulate and analyse the dynamic behavior of a simple renewable energy system.

**LO4 Investigate the impacts of renewable resources to the grid and the various issues associated with integrating such resources to the grid**

*Impact of renewable resources:*
Safe and secure operation of a simple power system. Standalone and grid connected renewable energy systems. Introduction to smart grid, features, functions, architectures, and distributed generation. Grid interactive systems, grid tied systems, inverters, and application of its devices. Smart homes, power management, smart grid, intelligent metering. Communication technologies and power electronics modules for smart grid network, importance of power electronics in smart grid, for example energy storage (electrical, chemical, biological, and heat), and the future of smart grid. Use of Matlab/Simulink to model, simulate and analyse the dynamic behavior of a standard smart grid.

# INDUSTRIAL SYSTEMS

This unit presents a structured approach to the development of advanced electronic solutions in a range of industrial situations. An essential requirement here is the engineer's ability to utilise the most appropriate technology for each application, to ensure the most efficient monitoring and control of variables such as pressure, temperature and speed.
Among the topics included in this unit are techniques and applications of electrical and electronic engineering, as they apply to various branches of industry, such as component handling, controlling the speed or torque of a motor or responding to change of circumstances in a process.
On successful completion of this unit students will be able to describe system elements and consider their overall characteristics. This provides opportunity for analytically assessing the accuracy and repeatability of electronic instruments.

## UNIT CONTENT

**LO1 Describe the main elements of an electronically controlled industrial system**

*Fundamental concepts of industrial systems:*
Discrete control.
Input and output devices; open and closed loop systems. Describe the system elements and the principles and applications of important and representative AC and DC motors.

**LO2 Identify and specify the interface requirements between electronic, electrical and mechanical transducers and controllers**

*Interfacing and transducers:*
Discrete automation using relays and solenoids, AC and DC motors, pneumatic, hydraulic and electrical actuators, and other transducers and devices for measuring and comparing physical parameters. Interfacing between electrical, electronic and mechanical transducers.
Practical measurement using sensors and transducers, process actuators for temperature and pressure control.

**LO3 Apply practical and computer-based methods to design and test a measurement system**

*System modelling and analysis:*
The use of transfer functions to help predict the behaviour and constancy of an industrial process, including accuracy, resolution and tolerances, repeatability and stability, sensitivity and response time. Dealing with error and uncertainty in industrial systems.Use of computer packages in measurement and control, and dealing with uncertainty and errors in systems.

**LO4 Apply appropriate analytical techniques to predict the performance of a given system**
Consideration of current trends in technology, including the future of industrial systems, the impact of digital developments, the increase of wireless and remote control and the Internet of Things.

## FURTHER CONTROL SYSTEMS ENGINEERING

Control engineering is usually found at the top level of large projects in determining the engineering system performance specifications, the required interfaces, and hardware and software requirements. In most industries, stricter requirements for product quality, energy efficiency, pollution level controls and the general drive for improved performance, place tighter limits on control systems.

A reliable and high performance control system depends a great deal upon accurate measurements obtained from a range of transducers, mechanical, electrical, optical and, in some cases, chemical. The information provided is often converted into digital signals on which the control system acts to maintain optimum performance of the process.

The aim of this unit is to provide the student with the fundamental knowledge of the principles of control systems and the basic understanding of how these principles can be used to model and analyse simple control systems found in industry. The study of control engineering is essential for most engineering disciplines, including electrical, mechanical, chemical, aerospace, and manufacturing.

On successful completion of this unit students will be able to devise a typical three term
controller for optimum performance, grasp fundamental control techniques and how these can be used to predict and control the behaviour of a range of engineering processes in a practical way.

### UNIT CONTENT

**LO1 Examine the basic concepts of control systems and their contemporary applications**
*Background, terminology, underpinning principles and system basics:*
Brief history of control systems and their industrial relevance, control system terminology and identification, including plant, process, system, disturbances, inputs and outputs, initial time, additivity, homogeneity, linearity and stability. Basic control systems properties and configurations, classification and performance criteria of control systems. Block diagram representation of simple control systems and their relevance in industrial application. Principles of Transfer Function (TF) for open and closed loop systems, use of current computational tools for use in control systems (e.g. Matlab, Simuliunk, Labview).

**LO2 Explore the elements of a typical, high-level control system and its model development**

*Developing system applications:*
Simple mathematical models of electrical, mechanical and electro-mechanical systems.
Block diagram representation of simple control systems. Introduction of Laplace transform and its properties, simple first and second order systems and their dynamic responses. Modelling and simulation of simple first and second order control system using current computational tool (e.g. Matlab/Simulink).

**LO3 Analyse the structure and behaviour of typical control systems**

*System behaviour:*
Transient and steady behaviour of simple open loop and closed loop control systems in response to a unit step input. Practical closed loop control systems and the effect of external disturbances.Poles and zeros and their role in

the stability of control systems, steady-state error. Applicability of Routh-Hurwitz stability criterion. Use of current computational tools (e.g. Matlab, Simulink) to model, simulate and analyse the dynamic behaviour of simple open and closed loop control systems.

**LO4 Explain the application of control parameters to produce optimum performance of a control system**

*Control parameters and optimum performance:*
Introduction to the three-term PID controller, the role of a Proportional controller (P), Integral controller (I) and the Derivative controller (D). General block diagram representation and analysis, effects of each term, P-I-D, on first and second order systems.
Simple closed loop analysis of the different combinations of the terms in PID controllers, effect of the three terms on disturbance signals and an introduction to simple PID controller tuning methods. Modelling and simulation using current computational tools (e.g. Matlab,
Simuliunk, Labview) to analyse the effects of each P-I-D term, individually and in combination on a control system.

## ANALOGUE ELECTRONIC SYSTEMS

Analogue electronic systems are still widely used for a variety of very important applications and this unit explores some of the specialist applications of this technology.
The aim of this unit is to further develop students understanding of the application of analogue and digital devices in the design of electronic circuits. Students will investigate the design and testing of electronic systems based on a sound theoretical knowledge of the characteristics of electronic devices supported by Electronic Computer Aided Design (ECAD) tools, and then construct and test sample physical circuits. Students will be able to explain the characteristics of analogue and digital subsystems and the representation and processing of information within them.
Upon completion of this unit students will be aware of techniques employed in the design and evaluation of analogue and digital subsystems used in the development of complete electronic systems.

### UNIT CONTENT

**LO1 Design single stage analogue amplifier circuits to predict and measure, by simulation, the gain, frequency response and input and output resistances**

*Bipolar Junction Transistor models:*
The theory of operation of the Bipolar Junction Transistor (BJT), together with DC biasing conditions of BJT for linear amplifier applications. Characteristics of common emitter, common collector and common base amplifier configurations. DC hFE and small signal common emitter h-parameter model and the common emitter hydrid-π model of the BJT.

Show gm =~ IC/26mV for silicon BJT at room temperature.

*Bipolar Junction Transistor small signal amplifiers:*
Four-resistor BJT common-emitter amplifier and its predicted AC voltage gain. ECAD used to determine the mid-band voltage gain and input and output resistances. The effect of input, output and emitter decoupling capacitors and tuned L-C collector load.

*Bipolar Junction Transistor large signal amplifiers:*
Examples of class A, B, AB, C and D large signal amplifiers. Use of ECAD to investigate the characteristics of sample power amplifier circuits.

*Field Effect Transistor models:*
The theory of operation of the Field Effect Transistor (FET) and the Metal Oxide semiconductor FET (MOSFET). Application of FETs and MOSFETs in switching circuits and linear amplifiers, including complementary MOSFET stages. Apply FET AC equivalent circuit models. Examples of specific applications of FET that have been developed for specialist applications.

**LO2 Develop functional subsystems through an understanding of the characteristics of operational amplifiers**

*Operational amplifier components:*
Circuit configuration and the operation of the long-tailed pair differential amplifier, current mirror and class AB amplifiers and relate these to circuits of operational amplifiers published in manufacturers' data sheets.

*Operational amplifier characteristics:*
Characteristics of practical operational amplifiers, including open loop gain, input offset voltage, common mode input range, saturated output levels, slew rate and gain-bandwidth product. Describe the ideal operational amplifier model and relate these to the specifications of practical operational amplifiers. Characteristics of the operational

amplifier with negative feedback applied.

*Operational amplifier applications:*
Description of a range of subsystems, including the voltage comparator, inverting and non-inverting amplifier, summing amplifier, differential amplifier, linear voltage regulator, switched mode voltage regulator, differentiator, integrator, filters, sinusoidal oscillator, Schmitt trigger and Schmitt oscillator. Sub-system specifications and evaluations in time and frequency domains, as appropriate. Use of ECAD tools.

**LO3 Examine the characteristics of information represented in analogue and digital format to assess techniques for the conversion of signals between analogue and digital formats**

*The characteristics of information represented electronically:*
Comparison of the implications of capturing, processing and storing information represented by analogue signals and by digital data, including amplitude range, frequency range, accuracy, resolution, linearity, drift, noise and signal-to-noise ratio.

*Digital to analogue and analogue to digital converters:*
Evaluation and comparison of digital to analogue converters based on the binary weighted resistor and the R/2R ladder network techniques. Evaluate and comparison of analogue to digital converters based on the single ramp, successive approximation and parallel comparator (flash) techniques. Advantages of using non-linear conversion curves in communications applications. Techniques for multichannel operation using multiplexing and de-multiplexing techniques applied to both digital and analogue channels. Examples of commercially available converters and the implementation of analogue input and output ports to digital processing devices found within embedded systems.

**LO4 Design electronic circuits using physical components**

*Sub-system design, implementation and evaluation:*
Examples of electronic subsystems. Development of specifications to achieve a useful function and design of circuits to achieve this function. Simulation of design using ECAD tools. Building of circuits as designed, application of a range of appropriate bench tests to evaluate its operation, and comparing its actual operation to the design specifications and the simulation results.

## RESEARCH PROJECT

Completing a piece of research is an opportunity for students to showcase their intellect and talents. It integrates knowledge with different skills and abilities that may not have been assessed previously, which may include seeking out and reviewing original research papers, designing their own experimental work, solving problems as they arise, managing time, finding new ways of analysing and presenting data, and writing an extensive report. Research can always be a challenge but one that can be immensely fulfilling, an experience that goes beyond a mark or a grade, but extends into long-lasting areas of personal and professional development.

This unit introduces students to the skills necessary to deliver a complex, independently conducted research project that fits within an engineering context. On successful completion of this unit students will be able to deliver a complex and independent research project in line with the original objectives, explain the critical thinking skills associated with solving engineering problems, consider multiple perspectives in reaching a balanced and justifiable conclusion, and communicate effectively a research project's outcome. Therefore, students develop skills such as critical thinking, analysis, reasoning, interpretation, decision-making, information literacy, information and communication technology literacy, innovation, conflict resolution, creativity, collaboration, adaptability and written and oral communication.

### UNIT CONTENT

**LO1 Conduct the preliminary stages involved in the creation of an engineering research project**

*Setting up the research preliminaries:*
Project proposal. Developing a research question(s). Selection of project approach. Identification of project supervisor. Estimation of resource requirements, including possible sources of funding. Identification of project key objectives, goals and rationale. Development of project specification.

**LO2 Examine the analytical techniques used to work on all stages of the project and strategies required to overcome the challenges involved in a research project**

*Investigative skills and project strategies:*
Selecting the method(s) of collecting data. Data analysis and interpreting findings. Literature review. Engaging with technical literature. Technical depth. Multi-perspectives analysis. Independent thinking. Statement of resources required for project completion. Potential risk issues, including health and safety, environmental and commercial. Project management and key milestones.

**LO3 Reflect on the impact the research experience could have in enhancing personal or group performance within an engineering context**

*Research purpose:*

Detailed statement of project aims. Relevance of the research. Benefits and beneficiaries of the research.

**LO4 Explore the communication approach used for the preparation and presentation of the research project's outcomes**

*Reporting the research:*
Project written presentation. Preparation of a final project report. Writing research report.
Project oral presentation such as using short PowerPoint presentation to discuss the work and conclusions.