Syllabus

Electrical Engineering

Year 1 & Year 2

Kings Cornerstone International College

Unit 1: Engineering Design

Unit code	**K/615/1475**
Unit type	**Core**
Unit level	**4**
Credit value	**15**

Introduction

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.

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.

Among the topics included in this unit are: Gantt charts and critical path analysis, stakeholder requirements, market analysis, design process management, modelling and prototyping, manufacturability, reliability life cycle, safety and risk, management, calculations, drawings and concepts and ergonomics.

On successful completion of this unit students will be able to prepare an engineering design specification that satisfies stakeholders' requirements, implement best practice when analysing and evaluating possible design solutions, prepare a written technical design report, and present their finalised design to a customer or audience.

Learning Outcomes

By the end of this unit students will be able to:

1. Plan a design solution and prepare an engineering design specification in response to a stakeholder's design brief and requirements.
2. Formulate possible technical solutions to address the student-prepared design specification.
3. Prepare an industry-standard engineering technical design report.
4. Present to an audience a design solution based on the design report and evaluate the solution/presentation.

Essential Content

LO1 **Plan a design solution and 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

Use of relevant technical/engineering/industry standards within 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 to address the student-prepared design specification**

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 industry-standard engineering technical design report**

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 design solution based on the design report and evaluate the solution/presentation**

Communication and post-presentation review:

Selection of presentation tools

Analysis of presentation feedback

Strategies for improvement based on feedback

Learning Outcomes and Assessment Criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Plan a design solution and prepare an engineering design specification in response to a stakeholder's design brief and requirements</td><td rowspan="3">D1 Compare and contrast the completed design specification against the relevant industry standard specification</td></tr>
<tr><td>P1 Produce a design specification from a given design brief

P2 Explain the influence of the stakeholder's design brief and requirements in the preparation of the design specification

P3 Produce a design project schedule with a graphical illustration of the planned activities</td><td>M1 Evaluate potential planning techniques, presenting a case for the method chosen

M2 Demonstrate critical path analysis techniques in design project scheduling/planning and explain its use</td></tr>
<tr><td colspan="2">LO2 Formulate possible technical solutions to address the student-prepared design specification</td></tr>
<tr><td>P4 Explore industry standard evaluation and analytical tools in formulating possible technical solutions

P5 Use appropriate design techniques to produce a possible design solution</td><td>M3 Apply the principles of modelling, simulation and/or prototyping, using appropriate software, to develop an appropriate design solution</td><td>D2 Evaluate potential technical solutions, presenting a case for the final choice of solution</td></tr>
</table>

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO3 Prepare an industry-standard engineering technical design report</td><td rowspan="3">D3 Evaluate the effectiveness of the industry standard engineering technical design report for producing a fully compliant finished product</td></tr>
<tr><td>P6 Prepare an industry-standard engineering technical design report

P7 Explain the role of design specifications and standards in the technical design report</td><td>M4 Assess any compliance, safety and risk management issues specific to the technical design report</td></tr>
<tr><td colspan="2">LO4 Present to an audience a design solution based on the design report and evaluate the solution/presentation</td></tr>
<tr><td>P8 Present the recommended design solution to the identified audience

P9 Explain possible communication strategies and presentation methods that could be used to inform the stakeholders of the recommended solution</td><td>M5 Reflect on the effectiveness of the chosen communication strategy in presenting the design solution</td><td>D4 Justify potential improvements to the design solution and/or presentation based on reflection and/or feedback</td></tr>
</table>

Recommended Resources

Textbooks

DUL, J. and WEERDMEESTER, B. (2008) *Ergonomics for beginners*. 3rd Ed. Boca Raton: CRC Press.

DYM, C.L., LITTLE, P. and ORWIN, E. (2014) *Engineering Design: a Project Based Introduction*. 4th Ed. Wiley.

GRIFFITHS, B. (2003) *Engineering Drawing for Manufacture*. Kogan Page Science.

REDDY, K.V. (2008) *Textbook of Engineering Drawing*. 2nd Ed. Hyderabad: BS Publications.

Websites

www.epsrc.ac.uk	Engineering and Physical Sciences Research Council (General Reference)
www.imeche.org	Institution of Mechanical Engineers (General Reference)

Unit 2: Engineering Maths

Unit code	**M/615/1476**
Unit type	**Core**
Unit level	**4**
Credit value	**15**

Introduction

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.

Learning Outcomes

By the end of this unit students will be able to:

1. Identify the relevance of mathematical methods to a variety of conceptualised engineering examples.
2. Investigate applications of statistical techniques to interpret, organise and present data.
3. Use analytical and computational methods for solving problems by relating sinusoidal wave and vector functions to their respective engineering applications.
4. Examine how differential and integral calculus can be used to solve engineering problems.

Essential 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, trigonometric and hyperbolic functions

LO2 **Investigate applications of statistical techniques to interpret, organise and present data**

Summary of data:

Mean and standard deviation of grouped data

Pearson's correlation coefficient

Linear regression

Charts, graphs and tables to present data

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 application.**

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 **Examine how differential and integral calculus can be used to solve engineering problems**

Differential calculus:

Definitions and concepts

Definition of a function and of a derivative, graphical representation of a function, notation of derivatives, limits and continuity, derivatives; rates of change, increasing and decreasing functions and turning points

Differentiation of functions

Differentiation of functions including:

- standard functions/results
- using the chain, product and quotient rules
- second order and higher derivatives

Types of function: polynomial, logarithmic, exponential and trigonometric (sine, cosine and tangent), inverse trigonometric and hyperbolic functions

Integral calculus:

Definite and indefinite integration

Integrating to determine area

Integration of functions including:

- common/standard functions
- using substitution
- by parts

Exponential growth and decay

Types of function: algebraic including partial fractions and trigonometric (sine, cosine and tangent) functions

Engineering problems involving calculus:

Including: stress and strain, torsion, motion, dynamic systems, oscillating systems, force systems, heat energy and thermodynamic systems, fluid flow, AC theory, electrical signals, information systems, transmission systems, electrical machines, electronics

Learning Outcomes and Assessment Criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Identify the relevance of mathematical methods to a variety of conceptualised engineering examples</td><td rowspan="4">LO1 & LO2

D1 Present data in a method that can be understood by a non-technical audience</td></tr>
<tr><td>P1 Apply dimensional analysis techniques to solve complex problems

P2 Generate answers from contextualised arithmetic and geometric progressions

P3 Determine solutions of equations using exponential, logarithmic, trigonometric and hyperbolic functions</td><td>M1 Use dimensional analysis to derive equations</td></tr>
<tr><td colspan="2">LO2 Investigate applications of statistical techniques to interpret, organise and present data</td></tr>
<tr><td>P4 Summarise data by calculating mean and standard deviation

P5 Calculate probabilities within both binomially distributed and normally distributed random variables</td><td>M2 Interpret the results of a statistical hypothesis test conducted from a given scenario</td></tr>
</table>

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO3 Use analytical and computational methods for solving problems by relating sinusoidal wave and vector functions to their respective engineering application</td><td rowspan="2">D2 Model the combination of sine waves graphically and analyse the variation in results between graphical and analytical methods</td></tr>
<tr><td>P6 Solve engineering problems relating to sinusoidal functions

P7 Represent engineering quantities in vector form, and use appropriate methodology to determine engineering parameters</td><td>M3 Use compound angle identities to combine individual sine waves into a single wave</td></tr>
<tr><td colspan="2">LO4 Examine how differential and integral calculus can be used to solve engineering problems</td><td rowspan="2">D3 Analyse maxima and minima of increasing and decreasing functions using higher order derivatives</td></tr>
<tr><td>P8 Determine rates of change for algebraic, logarithmic and trigonometric functions

P9 Use integral calculus to solve practical problems relating to engineering</td><td>M4 Formulate predictions of exponential growth and decay models using integration methods</td></tr>
</table>

Recommended Resources

Textbooks

SINGH, K. (2011) *Engineering Mathematics Through Applications*. 2nd Ed. Basingstoke: Palgrave Macmillan.

STROUD, K.A. and BOOTH, D.J. (2013) *Engineering Mathematics*. 7th Ed. Basingstoke: Palgrave Macmillan.

Websites

http://www.mathcentre.ac.uk/	Maths Centre (Tutorials)
http://www.mathtutor.ac.uk/	Maths Tutor (Tutorials)

Unit 3: Engineering Science

Unit code	**T/615/1477**
Unit type	**Core**
Unit level	**4**
Credit value	**15**

Introduction

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.

Learning Outcomes

By the end of this unit students will be able to:

1. Examine scientific data using both quantitative and qualitative methods.
2. Determine parameters within mechanical engineering systems.
3. Explore the characteristics and properties of engineering materials.
4. Analyse applications of A.C./D.C. circuit theorems, electromagnetic principles and properties.

Essential Content

LO1 **Examine scientific data using both quantitative and qualitative 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

Test procedures for physical (destructive and non-destructive) tests and statistical tests that might be used in gathering information

Summarising 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 beams 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

Effects of sensible/latent heat of 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, polymers 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 A.C./D.C. circuit theorems, electromagnetic principles and properties**

D.C. circuit theory:

Voltage, current and resistance in D.C. networks

Exploring circuit theorems (Thevenin, Norton, Superposition), 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

Learning Outcomes and Assessment Criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Examine scientific data using both quantitative and qualitative methods</td><td rowspan="2">D1 Analyse scientific data using both quantitative and qualitative methods</td></tr>
<tr><td>P1 Describe SI units and prefix notation
P2 Examine quantitative and qualitative data with appropriate graphical representations</td><td>M1 Explain how the application of scientific method impacts upon different test procedures</td></tr>
<tr><td colspan="2">LO2 Determine parameters within mechanical engineering systems</td><td rowspan="2">D2 Compare how changes in the thermal efficiency of a given system can affect its performance.</td></tr>
<tr><td>P3 Determine the support reactions of a beam carrying a combination of a concentrated load and a uniformly distributed load
P4 Use Archimedes' principle in contextual engineering applications
P5 Determine the effects of heat transfer on the dimensions of given materials</td><td>M2 Determine unknown forces by applying d'Alembert's principle to a free body diagram</td></tr>
</table>

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO3 Explore the characteristics and properties of engineering materials</td><td rowspan="2">D3 Compare and contrast theoretical material properties of metals and non-metals with practical test data</td></tr>
<tr><td>P6 Describe the structural properties of metals and non-metals with reference to their material properties

P7 Explain the types of degradation found in metals and non-metals</td><td>M3 Review elastic and electromagnetic hysteresis in different materials</td></tr>
<tr><td colspan="2">LO4 Analyse applications of A.C./D.C. circuit theorems, electromagnetic principles and properties</td><td rowspan="2">D4 Evaluate different techniques used to solve problems on a combined series-parallel RLC circuit using A.C. theory.</td></tr>
<tr><td>P8 Calculate currents and voltages in D.C. circuits using circuit theorems

P9 Describe how complex waveforms are produced from combining two or more sinusoidal waveforms.

P10 Solve problems on series RLC circuits with A.C. theory.</td><td>M4 Explain the principles and applications of electromagnetic induction</td></tr>
</table>

Recommended Resources

Textbooks

BIRD, J. (2012) *Science for Engineering*. 4th Ed. London: Routledge.

BOLTON, W. (2006) *Engineering Science*. 5th Ed. London: Routledge.

TOOLEY, M. and DINGLE, L. (2012) *Engineering Science: For Foundation Degree and Higher National*. London: Routledge.

Journals

International Journal of Engineering Science.

International Journal of Engineering Science and Innovative Technology.

Websites

https://www.khanacademy.org/	Khan Academy Physics (Tutorials)

Unit 4: Managing a Professional Engineering Project

Unit code	**A/615/1478**
Unit type	**Core**
Unit level	**4**
Credit value	**15**

Introduction

The responsibilities of the engineer go far beyond completing the task in hand. Reflecting on their role in a wider ethical, environmental and sustainability context starts the process of becoming a professional engineer – a vial requirement for careerprogression.

Engineers seldom work in isolation and most tasks they undertake require a range of expertise, designing, developing, manufacturing, constructing, operating and maintaining the physical infrastructure and content of our world. The bringing together of these skills, expertise and experience is often managed through the creation of a 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 students 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.

This unit is assessed by a Pearson-set theme. The project brief will be set by the centre, based on a theme provided by Pearson (this will change annually). The theme and chosen project within the theme will enable students to explore and examine a relevant and current topical aspect of professional engineering.

**Please refer to the accompanying Pearson-set Assignment Guide and the Theme Release document for further support and guidance on the delivery ofthe Pearson-set unit.*

Learning Outcomes

By the end of this unit students will be able to:

1. Formulate and plan a project that will provide a solution to an identifiedengineering problem.
2. Conduct planned project activities to generate outcomes which provide a solution to the identified engineering problem.
3. Produce a project report analysing the outcomes of each of the project processes and stages.
4. Present the project report drawing conclusions on the outcomes of the project.

Essential Content

LO1 Formulate and plan a project that will provide a solution to an identifiedengineering problem

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 ofEthical 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 asolution to the identified engineering problem

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 ofEthical Principles

The National Society for Professional Engineers' Code of Ethics

LO3 Produce a project report analysing the outcomes of each of the projectprocesses 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 drawing conclusions on the outcomes of theproject

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 on-going professional practice

Reflective writing:

Avoiding generalisation and focusing on personal development and the research journey in a critical and objective way

Learning Outcomes and Assessment Criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Formulate and plan a project that will provide a solution to an identified engineering problem</td><td rowspan="2">D1 Illustrate the effect of legislation and ethics in developing the project plan</td></tr>
<tr><td>P1 Select an appropriate engineering based project, giving reasons for the selection
P2 Create a project plan for the engineering project</td><td>M1 Undertake a feasibility study to justify project selection</td></tr>
<tr><td colspan="2">LO2 Conduct planned project activities to generate outcomes which provide a solution to the identified engineering problem</td><td rowspan="2">D2 Critically evaluate the success of the project plan making recommendations for improvements</td></tr>
<tr><td>P3 Conduct project activities, recording progress against original project plan</td><td>M2 Explore alternative methods to monitor and meet project milestones, justify selection of chosen method(s)</td></tr>
<tr><td colspan="2">LO3 Produce a project report analysing the outcomes of each of the project processes and stages</td><td rowspan="4">LO3 & LO4
D3 Critically analyse the project outcomes making recommendations for further development</td></tr>
<tr><td>P4 Produce a project report covering each stage of the project and analysing project outcomes</td><td>M3 Use appropriate critical analysis and evaluation techniques to analyse project findings</td></tr>
<tr><td colspan="2">LO4 Present the project report drawing conclusions on the outcomes of the project</td></tr>
<tr><td>P5 Present the project report using appropriate media to an audience</td><td>M4 Analyse own behaviours and performance during the project and suggest areas for improvement</td></tr>
</table>

Recommended Resources

Textbooks

PUGH, P. S. (1990) *Total Design: Integrated Methods for Successful Product Engineering*. Prentice Hall.

STRIEBIG, B., OGUNDIPE, A. and PAPADAKIS, M. (2015) *Engineering Applications inSustainable Design and Development*. Cengage Learning.

ULRICH, K. and EPPINGER, S. (2011) *Product Design and Development*. 5th Ed. McGraw-Hill Higher Education.

Journals

Journal of Engineering Design.

Links

This unit links to the following related units:

Unit 34: Research Project

Unit 35: Professional Engineering Management

Unit 19: Electrical and Electronic Principles

Unit code	**M/615/1493**
Unit level	**4**
Credit value	**15**

Introduction

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.

On successful completion of this unit students will have a good and wide-ranging grasp of the underlying principles of electrical and electronic circuits and devices, and will be able to proceed with confidence to further study.

Learning Outcomes

By the end of this unit students will be able to:

1. Apply an understanding of fundamental electrical quantities to evaluate circuits with constant voltages and currents.
2. Evaluate circuits with sinusoidal voltages and currents.
3. Describe the basis of semiconductor action, and its application to simple electronic devices.
4. Explain the difference between digital and analogue electronics, describing simple applications of each.

Essential Content

LO1 **Apply an understanding of fundamental electrical quantities to analyse 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 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, emphasising 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

Simple semiconductor applications:

Diodes: AC-DC rectification, light emitting diode, voltage regulation

Transistors: switches and signal amplifiers

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

Learning Outcomes and Assessment Criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Apply an understanding of fundamental electrical quantities to analyse circuits with constant voltages and currents</td><td rowspan="2">D1 Evaluate the operation of a range of circuits with constant sources, using relevant circuit theories.</td></tr>
<tr><td>P1 Apply the principles of circuit theory to simple circuits with constant sources, to explain the operation of that circuit</td><td>M1 Apply the principles of circuit theory to a range of circuits with constant sources, to explain the operation of that circuit</td></tr>
<tr><td colspan="2">LO2 Analyse circuits with sinusoidal voltages and currents</td><td rowspan="2">D2 Analyse the operation and behaviour of series and parallel RLC circuits, including resonance and using the principles of circuit theory with sinusoidal sources.</td></tr>
<tr><td>P2 Analyse series RLC circuits, using the principles of circuit theory with sinusoidal sources.</td><td>M2 Analyse series and parallel RLC circuits, using the principles of circuit theory with sinusoidal sources.</td></tr>
<tr><td colspan="2">LO3 Describe the basis of semiconductor action, and its application to simple electronic devices</td><td rowspan="2">D3 Analyse the performance of a range of discrete semiconductor devices in terms of simple semiconductor theory, and suggest applications for each.</td></tr>
<tr><td>P3 Describe the behaviour of a p-n junction in terms of semiconductor behaviour
P4 Demonstrate the action of a range of semiconductor devices</td><td>M3 Explain the operation of a range of discrete semiconductor devices in terms of simple semiconductor theory</td></tr>
</table>

Pass	Merit	Distinction
LO4 Explain the difference between digital and analogue electronics, describing simple applications of each		**D4** Evaluate the use of analogue and digital devices and circuits using examples.
P5 Explain the difference between digital and analogue electronics **P6** Explain amplifier characteristics **P7** Explain the operation of a simple circuit made of logic gates	**M4** Explain the benefits of using analogue and digital electronic devices using examples	

Recommended Resources

Textbooks

BIRD, J. (2013) *Electrical Circuit Theory and Technology*. Routledge.

HUGHES, E., HILEY, J., BROWN, K. and MCKENZIE-SMITH, I. (2012) *Electrical and Electronic Technology*. Pearson.

SINGH, K. (2011) *Engineering Mathematics through Applications*. Palgrave.

Pearson BTEC Higher Nationals Study Guide (2011) Custom Publishing. Pearson.

Unit 34: Research Project

Unit code	**J/615/1502**
Unit type	**Core**
Unit level	**5**
Credit value	**30**

Introduction

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.

Learning Outcomes

By the end of this unit students will be able to:

1. Conduct the preliminary stages involved in the creation of an engineering research project.
2. 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.
3. Reflect on the impact the research experience could have in enhancing personal or group performance within an engineering context.
4. Explore the communication approach used for the preparation and presentation of the research project's outcomes.

Essential 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 presentation to discuss the work and conclusions

Learning Outcomes and Assessment Criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Conduct the preliminary stages involved in the creation of an engineering research project</td><td rowspan="3">D1 Produce a comprehensive project proposal that evaluates and justifies the rationale for the research</td></tr>
<tr><td>P1 Produce a research project proposal that clearly defines a research question or hypothesis

P2 Discuss the key project objectives, the resulting goals and rationale</td><td>M1 Analyse the project specification and identify any project risks</td></tr>
<tr><td colspan="2">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</td></tr>
<tr><td>P3 Conduct a literature review of published material, either in hard copy or electronically, that is relevant to your research project

P4 Examine appropriate research methods and approaches to primary and secondary research</td><td>M2 Analyse the strategies used to overcome the challenges involved in the literature review stage

M3 Discuss merits, limitations and pitfalls of approaches to data collection and analysis</td><td>D2 Critically analyse literature sources utilised, data analysis conducted and strategies to deal with challenges</td></tr>
</table>

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO3 Reflect on the impact the research experience could have in enhancing personal or group performance within an engineering context</td><td rowspan="2">D3 Critically evaluate how the research experience enhances personal or group performance within an engineering context</td></tr>
<tr><td>P5 Reflect on the effectiveness and the impact the experience has had upon enhancing personal or group performance</td><td>M4 Evaluate the benefits from the findings of the research conducted</td></tr>
<tr><td colspan="2">LO4 Explore the communications approach used for the preparation and presentation of the research project's outcomes</td><td rowspan="2">D4 Critically reflect how the audience for whom the research was conducted influenced the communication approach used for the preparation and presentation of the research project's outcomes</td></tr>
<tr><td>P6 Explore the different types of communications approaches that can be used to present the research outcomes
P7 Communicate research outcomes in an appropriate manner for the intended audience</td><td>M5 Evaluate how the communication approach meets research project outcomes and objectives</td></tr>
</table>

Recommended Resources

Textbooks

LEONG, E.C., LEE-HSIA, C.H. and WEE ONG, K.K. (2015) *Guide to Research Projects for Engineering Students: Planning, Writing and Presenting*.
Apple Academic Press Inc.

OBERLENDER, G.D. (2014) *Project Management for Engineering and Construction*. 3rd Ed.
McGraw-Hill Education.

Websites

https://www.apm.org.uk/	Association for Project Management (General Reference)

Unit 35: Professional Engineering Management

Unit code	**L/615/1503**
Unit type	**Core**
Unit level	**5**
Credit value	**15**

Introduction

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 *Unit 4: 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.

This unit is assessed by a Pearson-set theme. The project brief will be set by the centre, based on a theme provided by Pearson (this will change annually). The theme and chosen project within the theme will enable students to explore and examine a relevant and current topical aspect of professional engineering.

***Please refer to the accompanying Pearson-set The Guide and the Theme Release document for further support and guidance on the delivery of the Pearson-set unit.**

Learning Outcomes

By the end of this unit students will be able to:

1. Evaluate the risk evaluation theories and practices associated with the management of projects for the production of current and developing technology.
2. Produce an engineering services delivery plan that meets the requirements of a sector-specific organisation.
3. Develop effective leadership, individual and group communication skills.
4. Develop personal commitment to professional standards and obligations to society, the engineering profession and the environment.

Essential 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:

Organisational 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 organisation**

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)

Learning Outcomes and Assessment Criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Evaluate the risk evaluation theories and practices associated with the management of projects for the production of current and developing technology</td><td rowspan="3">D1 Specify and analyse the challenges encountered when meeting the requirements for successfully managing engineering activities, and make justified recommendations to overcome these challenges</td></tr>
<tr><td>P1 Evaluate the risk evaluation theories and practices associated with the management of engineering projects

P2 Assess elements and issues that impact the successful management of engineering activities</td><td>M1 Critically evaluate the main elements and issues that impact the successful management of engineering activities</td></tr>
<tr><td colspan="2">LO2 Produce an engineering services delivery plan that meets the requirements of a sector-specific organisation</td></tr>
<tr><td>P3 Develop an engineering services delivery plan, applying the appropriate sector-specific requirements

P4 Determine the engineering management tools needed for designing an engineering services delivery plan</td><td>M2 Evaluate how each step of the delivery plan developed meets the requirements of a sector specific organisation</td><td>D2 Critically evaluate contingencies that might prevent the delivery plan meeting the requirements of a sector-specific organisation</td></tr>
</table>

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO3 Develop effective leadership, individual and group communication skills</td><td rowspan="2">D3 Critically evaluate effective ways for the coaching and mentoring of disillusioned colleagues or of a poorly performing team</td></tr>
<tr><td>P5 Describe the steps for effective persuasion and negotiation
P6 Explain the steps for managing effective group meetings
P7 Outline the steps to deliver an effective presentation</td><td>M3 Evaluate leadership styles and effective communication skills using specific examples in an organisational context</td></tr>
<tr><td colspan="2">LO4 Develop personal commitment to professional standards and obligations to society, the engineering profession and the environment</td><td rowspan="2">D4 Evaluate and provide justifications on why it is necessary to be active and up to date with the engineering profession's new developments and discoveries</td></tr>
<tr><td>P8 Discuss the context of social responsibility for scientists and engineers
P9 Explore the ways in which an engineer can engage in continuing professional development</td><td>M4 Summarise the engineering profession ethical standards and patterns of behaviour</td></tr>
</table>

Recommended Resources

Textbooks

BURNS, B. (2014) *Managing Change*. 6th Ed. Pearson.

DEARDEN, H. (2013) *Professional Engineering Practice: Reflections on the Role of the Professional Engineer*. CreateSpace Independent Publishing Platform.

KARTEN, N. (2010) *Presentation Skills for Technical Professionals*. IT Governance Ltd.

LOCK, D. (2013) *Project Management*. 10th Ed. Routledge.

Websites

http://www.engc.org.uk/	Engineering Council UK-SPEC UK Standard for Professional Engineering Competence (E-Books)
http://www.ewb-uk.org/	Engineering without Borders (General Reference)

Unit 39: Further Mathematics

Unit code	**H/615/1507**
Unit level	**5**
Credit value	**15**

Introduction

The understanding of more advanced mathematics is important within an engineering curriculum to support and broaden abilities within the applied subjects at the core of all engineering programmes. Students are introduced to additional topics that will be relevant to them as they progress to the next level of their studies, advancing their knowledge of the underpinning mathematics gained in *Unit 2: Engineering Maths*.

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.

Learning Outcomes

By the end of this unit students will be able to:

1. Use applications of number theory in practical engineering situations.
2. Solve systems of linear equations relevant to engineering applications using matrix methods.
3. Approximate solutions of contextualised examples with graphical and numerical methods.
4. Review models of engineering systems using ordinary differential equations.

Essential 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 and 3x3 matrix

Using the inverse of a square matrix to solve linear equations

Gaussian elimination to solve systems of linear equations (up t 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

Learning Outcomes and Assessment Criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Use applications of number theory in practical engineering situations</td><td rowspan="2">D1 Test the correctness of a trigonometric identity using de Moivre's Theorem</td></tr>
<tr><td>P1 Apply addition and multiplication methods to numbers that are expressed in different base systems

P2 Solve engineering problems using complex number theory

P3 Perform arithmetic operations using the polar and exponential form of complex numbers</td><td>M1 Solve problems using de Moivre's Theorem</td></tr>
<tr><td colspan="2">LO2 Solve systems of linear equations relevant to engineering applications using matrix methods</td><td rowspan="2">D2 Validate solutions for the given engineering linear equations using appropriate computer software</td></tr>
<tr><td>P4 Calculate the determinant of a set of given linear equations using a 3x3 matrix

P5 Solve a system of three linear equations using Gaussian elimination</td><td>M2 Determine the solution to a set of given engineering linear equations using the Inverse Matrix Method for a 3x3 matrix</td></tr>
</table>

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO3 Approximate solutions of contextualised examples with graphical and numerical methods</td><td rowspan="2">D3 Critically evaluate the use of numerical estimation methods, commenting on their applicability and the accuracy of the methods</td></tr>
<tr><td>P6 Estimate solutions of sketched functions using a graphical estimation method

P7 Calculate the roots of an equation using two different iterative techniques

P8 Determine the numerical integral of engineering functions using two different methods</td><td>M3 Solve engineering problems and formulate mathematical models using graphical and numerical integration</td></tr>
<tr><td colspan="2">LO4 Review models of engineering systems using ordinary differential equations</td><td rowspan="2">D4 Critically evaluate first and second-order differential equations when generating the solutions to engineering situations using models of engineering systems</td></tr>
<tr><td>P9 Formulate and solve first order differential equations related to engineering systems

P10 Formulate and solve second order homogeneous and non-homogeneous differential equations related to engineering systems

P11 Calculate solutions to linear ordinary differential equations using Laplace transforms</td><td>M4 Demonstrate how different models of engineering systems using first-order differential equations can be used to solve engineering problems</td></tr>
</table>

Recommended Resources

Textbooks

BIRD, J. (2014) *Higher Engineering Mathematics*. 7th Ed. London: Routledge.

SINGH, K. (2011) *Engineering Mathematics Trough Applications*. Basingstoke, Palgrave Macmillan.

STROUD, K.A. and BOOTH, D.J. (2013) *Engineering Mathematics*. 7th Ed: Basingstoke, Palgrave Macmillan.

Journals

Communications on Pure and Applied Mathematics. Wiley.

Journal of Engineering Mathematics. Springer.

Journal of Mathematical Physics. American Institute of Physics.

Websites

http://www.mathcentre.ac.uk/	Maths Centre (Tutorials)
http://www.mathtutor.ac.uk/	Maths Tutor (Tutorials)

Unit 44: Industrial Power, Electronics and Storage

Unit code	**M/615/1512**
Unit level	**5**
Credit value	**15**

Introduction

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.

Learning Outcomes

By the end of this unit students will be able to:

1. Evaluate energy demand to determine the technology and methods of energy production.
2. Discuss current energy efficiency measures, technologies and policies specific to the building and transportation sectors.
3. Analyse the control techniques of power electronics for renewable energy systems.
4. Investigate the impacts of renewable resources to the grid and the various issues associated with integrating such resources to the grid.

Essential 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 behaviour 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 behaviour of a standard smart grid.

Learning Outcomes and Assessment Criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Evaluate the energy demand to determine the technology and methods of energy production</td><td rowspan="2">D1 Critically evaluate the performance of a renewable energy system and the technologies used in energy efficiency improvement</td></tr>
<tr><td>P1 Investigate current energy sources, demand and their impact on the environment
P2 Examine the benefits and effectiveness of renewable energy sources
P3 Explore renewable energy technologies and their costs</td><td>M1 Determine the use of energy sources to assess their global impact on energy demand
M2 Evaluate the effectiveness and drawbacks of renewable energy systems for short and long term energy demands</td></tr>
<tr><td colspan="2">LO2 Explore current energy efficiency measures, technologies and policies specific to the building and transportation sectors</td><td rowspan="2">D2 Analyse the dynamic performance of a power electronic converter for a given renewable energy source and calculate the energy and cost savings against conventional power sources, including consideration for development and installation costs</td></tr>
<tr><td>P4 Discuss current energy efficiency measures
P5 Determine the main factors that impact on energy use and efficiency in a building
P6 Discuss the technologies that could be used to support more sustainable transport</td><td>M3 Apply modelling of energy management in a building or electric vehicle using Matlab/Simulink (or equivalent)
M4 Evaluate the selection of suitable technologies to improve energy efficiency in a building or electric vehicle</td></tr>
</table>

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO3 Analyse the control techniques of power electronics for renewable energy systems</td><td rowspan="2">D3 Critically evaluate the dynamic performance of integrating renewable energy sources to the smart grid network using a standard industrial based software, such as Matlab/Simulink software (or equivalent)</td></tr>
<tr><td>P7 Analyse the applications of power electronics in renewable energy applications

P8 Determine the industrial application of power electronic converters

P9 Analyse the power electronic converter topologies and their principles of operation</td><td>M5 Simulate a simple power converter for a typical renewable energy system using a standard software package such as Matlab/Simulink (or equivalent)

M6 Critically analyse the use of the power converter selected above for a renewable energy application</td></tr>
<tr><td colspan="2">LO4 Investigate the impacts of renewable resources to the grid and the various issues associated with integrating such resources to the grid</td><td rowspan="2">D4 Critically analyse the impact of renewable energy sources and their integration to the grid using a standard industrial based software such as Matlab/Simulink (or equivalent)</td></tr>
<tr><td>P10 Investigate the safe operation of a smart power system

P11 Investigate the principle of operation of standalone and grid connected renewable energy systems

P12 Discuss the features of a smart grid network

P13 Determine the importance of power electronics in smart grid and energy storage</td><td>M7 Analyse how power electronic converters are used in smart grid networks

M8 Evaluate the issues associated with integrating renewable energy sources to the grid</td></tr>
</table>

Recommended Resources

Textbooks

ABU-RUB, H., MALINOWSKI, M. and AL-HADDAD, K. (2014) *Power Electronics for Renewable Energy Systems, Transportation and Industrial Applications*. John Wiley & Sons.

EKANAYAKE, J. and JENKINS, N. (2012) *Smart Grid Technology and Applications*. John Wiley & Sons.

RASHID, M.H. (2013) *Power Electronics: Circuits, Devices and Applications*. 4th Ed. Pearson.

TWIDELL, J. and WEIR, T. (2006) *Renewable Energy Resources*. 2nd Ed. Taylor & Francis.

Unit 45: Industrial Systems

Unit code	**T/615/1513**
Unit level	**5**
Credit value	**15**

Introduction

The speed and efficiency of many industrial processes is due, largely, to the control systems selected for the application and the engineer's ability to apply the most appropriate technology for their operation.

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.

Learning Outcomes

By the end of this unit students will be able to:

1. Describe the main elements of an electronically controlled industrial system.
2. Identify and specify the interface requirements between electronic, electrical and mechanical transducers and controllers.
3. Apply practical and computer-based methods to design and test a measurement system.
4. Apply appropriate analytical techniques to predict the performance of a given system.

Essential 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

Learning Outcomes and Assessment Criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Describe the main elements of an electronically controlled industrial system</td><td rowspan="2">D1 Critically examine the performance of an electronically controlled system to make recommendations for improvement</td></tr>
<tr><td>P1 Describe the main elements of an electronically controlled industrial system
P2 Review the main concepts underlying electronically controlled industrial systems</td><td>M1 Analyse the characteristics of an electronically controlled industrial system by applying a variety of techniques to the solution of a given problem</td></tr>
<tr><td colspan="2">LO2 Identify and specify the interface requirements between electronic, electrical and mechanical transducers and controllers</td><td rowspan="2">D2 Critically investigate the behaviour of a given control system to compare different electrical, electronic, and mechanical approaches to control</td></tr>
<tr><td>P3 Identify the interface requirements between electronic, electrical and mechanical transducers and controllers
P4 Justify the choice of transducers and controllers for a given task</td><td>M2 Predict the behaviour of an electronically controlled industrial system by applying a variety of transducers to the solution of a given problem and choose a 'best' solution</td></tr>
<tr><td colspan="2">LO3 Apply practical and computer-based methods to design and test a measurement system</td><td rowspan="2">D3 Critically evaluate the performance of an ideal measurement system compared to a real circuit</td></tr>
<tr><td>P5 Apply practical and computer-based methods to design and test a measurement system
P6 Explain the use of practical and analytical methods in creating and testing a measurement system</td><td>M3 Interpret the characteristics and behaviour of an existing electronic measurement system by applying a variety of methods to find a solution to a given problem</td></tr>
</table>

Pass	Merit	Distinction
LO4 Apply appropriate analytical techniques to predict the performance of a given system		**D4** Analyse an existing industrial system by using appropriate analytical techniques Provide justified recommendations to improve the performance
P7 Apply the main analytical techniques to explain the performance of a given system	**M4** Evaluate the characteristics of an electronically controlled industrial system by applying a variety of analytical techniques to the solution of a given problem	

Recommended Resources

Textbooks

BIRD, J. (2013) *Electrical Circuit Theory and Technology*. Routledge.

HUGHES, E. et al. (2012) *Electrical and Electronic Technology*. Pearson.

REHG, J.A. and SARTORI, G.J. (2005) *Industrial Electronics*. Prentice-Hall.

WILAMOWSKI, B.M. and IRWIN, J.D. (2011) *The Industrial Electronic Handbook: Fundamentals of Industrial Electronics*. CRC Press.

Websites

http://www.bath.ac.uk/	University of Bath Patents (General Reference)
http://www.bsigroup.com/	Business Standards Institution Standards Catalogue (General Reference)
https://www.ieee.org/	Institute of Electrical and Electronics Engineers Standards (General Reference)
http://www.theiet.org/	Institution of Engineering and Technology (General Reference)
http://www.newelectronics.co.uk/	New Electronics Digital Magazine (Journals)
http://www.theiet.org/	Institution of Engineering and Technology (Journals)
http://www.epemag.com/	Everyday Practical Electronics (Journals)
https://www.ieee.org/	Institute of Electrical and Electronics Engineers (Journals)

Electives

Unit 20: Digital Principles

Unit code	**T/615/1494**
Unit level	**4**
Credit value	**15**

Introduction

While the broad field of electronics covers many aspects, it is digital electronics which now has the greatest impact. This is immediately evident in the mobile phone, laptop, and numerous other everyday devices and systems. Digital electronics allows us to process, store, and transmit data in digital form in robust ways, which minimises data degradation.

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, 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.

Learning Outcomes

By the end of this unit students will be able to:

1. Explain and analyse simple combinational logic circuits.
2. Explain and analyse simple sequential logic circuits.
3. Describe and evaluate the technologies used to implement digital electronic circuits.
4. Describe and analyse a range of digital subsystems, hence establishing the building blocks for larger systems.

Essential 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

Learning Outcomes and Assessment Criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Explain and analyse simple combinational logic circuits</td><td rowspan="2">D1 Analyse, optimise and enhance combinational logic circuits, making best use of Truth Table, Boolean Algebra and Karnaugh Map</td></tr>
<tr><td>P1 Explain and analyse the operation of a simple combinational logic circuit, making limited use of Truth Table, Boolean Algebra and Karnaugh Map</td><td>M1 Analyse and optimise the operation of a combinational logic circuit making good use of Truth Table, Boolean Algebra and Karnaugh Map</td></tr>
<tr><td colspan="2">LO2 Explain and analyse simple sequential logic circuits</td><td rowspan="2">D2 Analyse, optimise and enhance a sequential logic circuit, making use of Timing Diagrams</td></tr>
<tr><td>P2 Explain and analyse the operation of a simple sequential logic circuit, making use of Timing Diagrams</td><td>M2 Analyse and optimise a simple sequential logic circuit, making use of Timing Diagrams</td></tr>
<tr><td colspan="2">LO3 Describe and evaluate the technologies used to implement digital electronic circuits</td><td rowspan="2">D3 Apply lab equipment to configure, test and evaluate digital circuits, comparing and evaluating characteristics of different technologies</td></tr>
<tr><td>P3 Apply lab equipment to describe and evaluate simple digital circuits</td><td>M3 Apply lab equipment to configure and test simple digital circuits</td></tr>
</table>

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO4 Describe and analyse a range of digital subsystems, hence establishing the building blocks for larger systems</td><td rowspan="2">D4 Describe and critically evaluate a range of different logic subsystems, comparing these with other techniques or subsystems available, indicating the place they might take in a larger system</td></tr>
<tr><td>P4 Describe and analyse the principles of a range of different logic subsystems</td><td>M4 Describe and analyse a range of different logic subsystems, indicating the place they might take in a larger system</td></tr>
</table>

Recommended Resources

Textbooks

FLOYD, T.L. (2015) *Digital Fundamentals*. Pearson.

HUGHES, E., HILEY, J., BROWN, K. and MCKENZIE-SMITH, I. (2012) *Electrical and Electronic Technology*. Pearson.

Unit 22: Electronic Circuits and Devices

Unit code	**F/615/1496**
Unit level	**4**
Credit value	**15**

Introduction

Electronics is all around us today: in our homes, the workplace, cars and even on or in our bodies. It's hard to believe that it was only in 1947 that the transistor was developed by American physicists John Bardeen, Walter Brattain, and William Shockley. The invention of the transistor paved the way for cheaper radios, calculators and computers.

This unit introduces students to the use of electronics manufacturers' data to analyse the performance of circuits and devices, the operational characteristics of amplifier circuits, the types and effects of feedback on a circuit performance, and the operation and application of oscillators. They will also be introduced to the application of testing procedures to electronic devices and circuits, and use the findings of the tests to evaluate their operation.

Among the topics included in this unit are: power amplifiers, class A, B and AB; operational amplifiers, inverting, non-inverting, differential, summing, integrator, differentiator; types such as open, closed, positive and negative feedback; frequency, stability, frequency drift, distortion, amplitude, wave shapes and testing procedures.

On successful completion of this unit students will be able to determine the operational characteristics of amplifier circuits, investigate the types and effects of feedback on an amplifier's performance, examine the operation and application of oscillators and apply testing procedures to electronic devices and circuits.

Learning Outcomes

By the end of this unit students will be able to:

1. Determine the operational characteristics of amplifier circuits.
2. Investigate the types and effects of feedback on an amplifier's performance.
3. Examine the operation and application of oscillators.
4. Apply testing procedures to electronic devices and circuits.

Essential Content

LO1 **Determine the operational characteristics of amplifier circuits**

Operational characteristics:

Power amplifiers: class A, B and AB

Operational amplifiers: inverting, non-inverting, differential, summing, integrator, differentiator, comparator, instrumentation, Schmitt trigger, active filters

Gain, bandwidth, frequency response, input and output impedance

Distortion and noise

LO2 **Investigate the types and effects of feedback on an amplifier's performance**

Types and effects:

Types including open, closed, positive and negative feedback

Effect of feedback on gain, bandwidth, distortion, noise, stability, input and output impedance

LO3 **Examine the operation and application of oscillators**

Operation and application:

Types of oscillators such as Wien bridge, Twin-T, R-C ladder, L-C coupled, transistor, operational amplifier, crystal

Frequency, stability, frequency drift, distortion, amplitude and wave shapes

LO4 **Apply testing procedures to electronic devices and circuits**

Testing procedures:

Measuring performance, using practical results and computer simulations

Voltage gain, current, bandwidth, frequency response, output power, input and output impedance

Distortion and noise

Devices to test:

Semiconductors

Integrated circuits

Amplifiers

Oscillators

Filters

Power supplies

Integrated circuit (IC) voltage regulators

Combined analogue and digital IC's

Component manufacturer's data:

Specifications, manuals and circuit diagrams

Use of testing equipment:

Meters, probes and oscilloscopes

Signal generators and signal analysers, logic analysers

Virtual test equipment

Learning Outcomes and Assessment Criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Determine the operational characteristics of amplifier circuits</td><td rowspan="3">D1 Assess the results obtained from the application of practical and virtual tests on amplifier circuits studied</td></tr>
<tr><td>P1 Describe the types of amplifiers available and their applications
P2 Examine the different performance characteristics of types of amplifier</td><td>M1 Explain the results obtained from applying practical tests on an amplifier's performance</td></tr>
<tr><td colspan="2">LO2 Investigate the types and effects of feedback on an amplifier's performance</td></tr>
<tr><td>P3 Examine the types of feedback available and their effect on the amplifier's performance
P4 Describe a circuit which employs negative feedback</td><td>M2 Perform practical tests to show the effect of feedback on an amplifier's performance</td><td>D2 Evaluate the results of practical and virtual tests to analyse the effect of feedback on an amplifier's performance</td></tr>
<tr><td colspan="2">LO3 Examine the operation and application of oscillators</td><td rowspan="2">D3 Analyse the results obtained from applying practical and virtual tests on oscillators studied</td></tr>
<tr><td>P5 Examine types of available oscillators and their applications</td><td>M3 Assess the performance characteristics of types of oscillators</td></tr>
</table>

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO4 Apply testing procedures to electronic devices and circuits</td><td rowspan="2">D4 Analyse and compare the results obtained from applying practical and virtual tests on devices and circuits studied</td></tr>
<tr><td>P6 Select suitable electronic devices and their parent circuits and identify the appropriate manufacturer’s data sheets

P7 Interpret relevant information from manufacturer’s data when testing electronic devices and circuits</td><td>M4 Perform tests on electronic devices and circuits, recording results and recommending appropriate action</td></tr>
</table>

Recommended Resources

Textbooks

BOYLESTAD, R.L. and NASHELSKY, L. (2013) *Electronic Devices and Circuit Theory*. 11th Ed. Pearson.

FLOYD, T.L. and BUCHLA, D. (2013) *Electronics Fundamentals: Circuits, Devices & Applications*. 8th Ed. Pearson.

HOROWITZ, P. and HILL, W. (2015) *The Art of Electronics*. 3rd Ed. Cambridge University Press.

Websites

www.electronics-tutorials.ws	Electronic Tutorials Amplifiers (Tutorials)
www.learnabout-electronics.org	Learn About Electronics Amplifiers (Tutorials)
www.learnabout-electronics.org	Learn About Electronics Oscillators (Tutorials)
www.electronics-tutorials.ws	Electronic Tutorials Oscillators (Tutorials)
http://learn.mikroe.com/	Mikro Elektronika Introduction to checking componants (E-Book)

Unit 31: Electrical Systems and Fault Finding

Unit code	**A/615/1500**
Unit level	**4**
Credit value	**15**

Introduction

Electrical systems can be found in a very wide range of locations such as in manufacturing facilities, airports, transport systems, shopping centres, hotels and hospitals; people will come across them every day in their work place and at home. The system must take the electrical supply from the national grid, convert it to a suitable voltage and then distribute it safely to the various system components and uses such as electric motors, lighting circuits and environmental controls.

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.

Learning Outcomes

By the end of this unit students will be able to:

1. Investigate the constructional features and applications of electrical distribution systems.
2. Examine the types and applications of electrical motors and generators.
3. Analyse the types of lighting circuits available in the industry by assessing their practical application.
4. Explain the operating characteristics of electrical safety components.

Essential 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

Learning Outcomes and Assessment Criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Investigate the constructional features and applications of electrical distribution systems</td><td rowspan="3">D1 Analyse the operation of single and three-phase techniques in electrical distribution systems</td></tr>
<tr><td>P1 Describe the features of an electrical distribution system
P2 Review the electrical component symbols used in circuit diagrams
P3 Explain the different methods of single and three phase connections</td><td>M1 Summarise the methods of safe fault finding on an electrical distribution system</td></tr>
<tr><td colspan="2">LO2 Examine the types and applications of electrical motors and generators</td></tr>
<tr><td>P4 Explain the types of electrical motors and generators available
P5 Select suitable motors for various industrial applications
P6 Review the different methods of starting induction motors and synchronous machines</td><td>M2 Outline the efficiency of motors and generators</td><td>D2 Justify the selection of a motor for a specific industrial application</td></tr>
</table>

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO3 Analyse the types of lighting circuits available in the industry by assessing their practical application</td><td rowspan="2">D3 Evaluate the practical application of a specific type of lighting circuit</td></tr>
<tr><td>P7 Examine the types and construction of lighting devices

P8 Explore a suitable lighting type for a specific application, considering its characteristics</td><td>M3 Analyse the efficiency of lighting circuit designs</td></tr>
<tr><td colspan="2">LO4 Explain the operating characteristics of electrical safety components</td><td rowspan="2">D4 Validate the selection of suitable electrical safety devices for a specific industrial application</td></tr>
<tr><td>P9 Describe the operation, types and uses of electrical safety devices

P10 List suitable safety components for a specific application</td><td>M4 Determine the practical application of electrical safety devices in an industrial situation</td></tr>
</table>

Recommended Resources

Textbooks

HUGHES, A. (2013) *Electric Motors and Drives: Fundamentals, Types and Applications.* 4th Ed. Newnes.

Websites

https://ocw.mit.edu/	MIT open courseware Electric Machines (Tutorials)

Unit 40: Commercial Programming Software

Unit code	**K/615/1508**
Unit level	**5**
Credit value	**15**

Introduction

The use of Computer Aided Design (CAD) and simulation in the electronic and electrical engineering industry is ever growing. Commercial software packages enable an engineer to design, simulate, model and predict the outcome of a design before a product has been made. This enables time and cost savings in the development of a product whilst enabling the engineer to further develop their design.

The aim of this unit is to introduce students to the availability and use of commercial software packages within electronics engineering, including design, simulation, simple microprocessor programming and evaluation of the tools available.

On successful completion of this unit students will be able to research a range of software tools or applications to support engineering functions related to electronics, consider how a software package can be used to simulate the behaviour of an electronic circuits function, explain how to programme a microprocessor-based device to achieve a specified outcome/task, evaluate a specific electronics software tool/application, describe the types of commercial software available, compare the differences between a software simulation and a real-world circuit, and write simple commands to a microcontroller.

Learning Outcomes

By the end of this unit students will be able to:

1. Research a range of software application tools to determine how they can support electronic engineering functions effectively.
2. Explain how a software package can be used to simulate the behaviour of an electronic circuit function and compare the results to real components and circuits.
3. Programme a microprocessor-based device to achieve a specified outcome or task using commercially available software.
4. Evaluate an electronics software application tool to report on its ability to replicate the real world and the resource savings this can bring to an organisation.

Essential Content

LO1 **Research a range of software application tools to determine how they can support electronic engineering functions effectively**

Exposition of computer packages or applications:

Circuit design, simulation, testing and analysis

Printed circuit board layouts

Electronic design automation (EDA or ECAD)

Microcontroller programming, such as Programmable Intelligent Computers (PICs). Microcontroller function simulation, monitoring and testing

LO2 **Explain how a software package can be used to simulate the behaviour of an electronic circuit function and compare the results to real components or circuits**

Application of an industrial computer-aided design package:

Simulation and analysis of electronic circuits

PCB design:

Creation of schematic netlists of a given design and transfer to a PCB layout to make design created using computer-based tools

Build:

Component identification and handling

Develop soldering skills to be able to populate a printed circuit board

Test and comparison:

Application of test equipment to measure voltage, current and resistance
Systematic test, commission and fault finding methods

Compare simulated values with tested values, comparison criteria to include; function, behaviour, accuracy, response times and errors

LO3 **Programme a microprocessor-based device to achieve a specified outcome or task using commercially available software**

Introduction to microprocessors:

Introduction to: common languages, compilers and simulators in-circuit debugging

simple programming for exercises:

Digital inputs, simple user feedback

Simulation and debugging

Motor, relay and sound outputs

Communication

LO4 **Review an electronics software application tool to report on its ability to replicate the real world and the resource savings this can bring to an organisation**

Software application:

Software applications with specific industry examples incorporating ease of use, functions available, performance, reliability, quality and costs

Possible limiting factors in software systems, based on previous work undertaken in the unit

Current trends in simulation, testing and microprocessor development

Learning Outcomes and Assessment Criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Research a range of software application tools to determine how they can support electronic engineering functions effectively</td><td rowspan="2">D1 Evaluate the functions and benefits of a range of commercial software used in developing electrical engineering</td></tr>
<tr><td>P1 Examine the functions of commercial programming software
P2 Discuss the categories of commercial electrical and electronic software</td><td>M1 Analyse the effectiveness of a range of commercial software in supporting electronic engineering functions</td></tr>
<tr><td colspan="2">LO2 Explain how a software package can be used to simulate the behaviour of an electronic circuit function and compare the results to real components or circuits</td><td rowspan="2">D2 Critically evaluate the functionality of simulation in comparison to real components using a complex PCB layout</td></tr>
<tr><td>P3 Design a simple PCB layout using a software package
P4 Investigate and compare results produced in simulation to develop an analysis with the physical build</td><td>M2 Design a complex PCB layout with a good level of optimisation using a software package
M3 Evaluate functionality of simulation to show considered comparisons between testing and simulation</td></tr>
</table>

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO3 Programme a microprocessor-based device to achieve a specified outcome or task using commercially available software</td><td rowspan="2">D3 Critically evaluate the functionality of simulation by noting variations between testing and simulation</td></tr>
<tr><td>P5 Programme a microprocessor-based device to produce working code using appropriate software

P6 Test and review code used through simulation and in the hardware</td><td>M4 Make improvements to given examples to produce complex working code

M5 Evaluate code through simulation and in the hardware, demonstrating good competence of the software</td></tr>
<tr><td colspan="2">LO4 Review an electronics software application tool to report on its ability to replicate the real world and the resource savings this can bring to an organisation</td><td rowspan="2">D4 Critically analyse current and emerging applications of commercial software with clear application to industry examples, identifying trends and recognising technical and economic factors which influence developments</td></tr>
<tr><td>P7 Evaluate an electronics software application and its ability to replicate the real world, supported by industry specific examples and illustrating the resource savings implications offered by this approach</td><td>M6 Analyse an electronics software application and its ability to replicate the real world, supported by specific industry examples and illustrating the resource savings implications this has</td></tr>
</table>

Recommended Resources

Textbooks

BLUM, J. (2013) *Exploring Arduino*. Wiley.

PETRUZZELLIS, T. (2005) *Build your own electronics workshop*. McGraw-Hill.

ROBBINS, A. and MILLER, W.C. (2013) *Circuit analysis: theory and practice*. 5th Ed. International Ed. Clifton Park, N.Y.: Delmar.

RICHARDSON, M. and WALLACE, S. (2013) *Getting started with Raspberry Pi*. 1st Ed. Maker Media Inc.

Websites

https://www.circuitlab.com/	Circuit Lab Online schematic editor and circuit simulator (Training)

Unit 52: Further Electrical, Electronic and Digital Principles

Unit code	**L/615/1520**
Unit level	**5**
Credit value	**15**

Introduction

Almost every aspect of our lives relies on electrical powered, electronically controlled machines and devices, many of them digital in format. To properly understand how to make the most efficient use of these devices in a safe and economical way, it is vital to have a thorough knowledge of the underlying principles on which they rely.

This unit builds on the preliminary techniques and skills introduced in *Unit 19: Electrical, Electronic and Unit 20: Digital Principles*.

The emphasis in this unit will be in developing a structured approach to the analysis of AC single-phase and three-phase powered circuitry. This will help students to arrive at the solution in the most efficient way, with the greatest probability of it being correct. In addition, students will be introduced to the expanding use of computers, using specialised software to solve electrical, electronic and digital circuits. This will allow students to develop the necessary confidence and competence in the four key areas of mathematical techniques, circuit analysis, circuit simulation and laboratory practice.

Successful completion of this unit will enable students to cope with increasingly complex problems and prepare them for the challenge of Level 6 academic programmes.

Learning Outcomes

By the end of this unit students will be able to:

1. Use appropriate mathematical techniques to solve a range of electrical and electronic problems.
2. Apply appropriate circuit theorems to solve problems in electrical networks.
3. Use appropriate laboratory and computer simulation techniques to investigate both analogue and digital circuits and interpret the results.
4. Explain the characteristics of non-linear circuits to predict their behaviour under a variety of conditions.

Essential Content

LO1 **Use appropriate mathematical techniques to solve a range of electrical and electronic problems**

Formal steady state circuit analysis:

Determinants, mesh analysis and nodal analysis (and their comparison)

Analysis using ideal sources, superposition theorem

AC circuit analysis:

Complex notation, polar and Cartesian coordinates, RLC circuits

Advanced use of phasor diagrams

Power: instantaneous power, power factor, apparent power, the power triangle

LO2 **Apply appropriate circuit theorems to solve problems in electrical networks**

Three-phase theory:

Application of trigonometric methods to solution of phasor diagrams

Application of complex numbers to represent quantities in AC circuits

Single-phase representation

Solution of balanced three-phase circuits

Complex notation applied to three-phase, unbalanced loads, unconnected neutral point

Power, reactive power and power factor correction for three-phase systems

LO3 **Use appropriate laboratory and computer simulation techniques to investigate both analogue and digital circuits and interpret the results**

ECAD:

Use of computer modelling and simulation techniques to analyse and solve electronic, electrical and digital circuits, such as filters and amplifiers using operational amplifiers and discrete devices; digital logic circuit elements; and simple combination and sequential circuits

LO4 **Explain the characteristics of non-linear circuits to predict their behaviour under a variety of conditions**

Non-linear circuits:

Characteristics of linear and non-linear circuits, mathematical modelling of a number of semiconductor devices, including diodes, bipolar and Field Effect Transistors and how this can be used to predict their 'real' behaviour in practice

Mathematically modelling the behaviour of semiconductor diodes, bipolar transistors and Field Effect Transistors

Learning Outcomes and Assessment Criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Use appropriate mathematical techniques to solve a range of electrical and electronic problems</td><td rowspan="2">D1 Apply an accurate approach to problem solving with clear justification of methods used with a high standard of explanation for each method</td></tr>
<tr><td>P1 Produce basic solutions to electrical and electronic problems to a satisfactory standard, but with some misunderstandings</td><td>M1 Provide reasoned solutions to problems, showing a logical approach and using a range of mathematical methods</td></tr>
<tr><td colspan="2">LO2 Apply appropriate circuit theorems to solve problems in electrical networks</td><td rowspan="2">D2 Evaluate electrical theory by using a variety of mathematical and other methods to produce accurate solutions with clear justification of the methods used</td></tr>
<tr><td>P2 Use electrical network theory to provide solutions to problems to a satisfactory standard, with some level of ambiguity and errors</td><td>M2 Apply electrical network theory and provide accurate solutions to problems, showing a logical approach</td></tr>
<tr><td colspan="2">LO3 Use appropriate laboratory and computer simulation techniques to investigate both analogue and digital circuits and interpret the results</td><td rowspan="2">D3 Present a clear evaluation of the operation of current analogue and digital logic circuits by comparing their predicted behaviour with the simulated, theoretical and practical results</td></tr>
<tr><td>P3 Use appropriate laboratory and computer simulation techniques to explain the performance of digital logic circuits and analogue circuits</td><td>M3 Explore analogue and digital logic circuits to show a structured approach to the solutions of problems using a variety of methods</td></tr>
</table>

Pass	Merit	Distinction
LO4 Explain the characteristics of non-linear circuits to predict their behaviour under a variety of conditions		**D4** Evaluate the application of theory, simulation and practical investigation of a number of circuits using nonlinear circuits
P4 Describe the characteristics of non-linear circuits and how their behaviour differs in practice with 'ideal' devices	**M4** Investigate a variety of non-linear circuits by calculating the effects of non-linear behaviour in a number of differing circuits	

Recommended Resources

Textbooks

BIRD, J. (2013) *Electrical Circuit Theory and Technology*. Routledge.

HUGHES, E. et al. (2012) *Electrical and Electronic Technology*. Pearson.

REHG, J.A. and SARTORI, G.J. (2005) *Industrial Electronics*. Prentice-Hall.

WILAMOWSKI, B.M. and IRWIN, J.D. (2011) *The Industrial Electronic Handbook: Fundamentals of Industrial Electronics*. CRC Press.

Websites

http://www.bath.ac.uk/	University of Bath Patents (General Reference)
http://www.bsigroup.com	British Standards Institution Standards (General Reference)
https://www.ieee.org	Institute of Electrical and Electronics Engineers Standards (General Reference)
https://app.knovel.com/	Knovel (Research)
https://www.esdu.com	Engineering Science Data Unit (General Reference)
http://www.theiet.org/	Institute of Engineering and Technology (General Reference)
http://www.theiet.org/	Institute of Engineering and Technology (Journal)
http://www.newelectronics.co.uk/	New Electronics Digital Magazine (Journal)

http://www.electronicsworld.co.uk/	Electronics World Magazine (Journal)
http://tie.ieee-ies.org/	Industrial Economics Society (Journal)
http://www.epemag.com/	Everyday Practical Electronics Magazine (Journal)