Syllabus

Mechanical Engineering

Year 1 & Year 2

Kings Cornerstone International College

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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.

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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.

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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

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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

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Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Plan a design solution and prepare an engineering design specification in response to a stakeholder's design brief and requirements		**D1** Compare and contrast the completed design specification against the relevant industry standard specification
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	**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	
LO2 Formulate possible technical solutions to address the student-prepared design specification		**D2** Evaluate potential technical solutions, presenting a case for the final choice of solution
P4 Explore industry standard evaluation and analytical tools in formulating possible technical solutions **P5** Use appropriate design techniques to produce a possible design solution	**M3** Apply the principles of modelling, simulation and/or prototyping, using appropriate software, to develop an appropriate design solution	

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Pass	Merit	Distinction
LO3 Prepare an industry-standard engineering technical design report		**D3** Evaluate the effectiveness of the industry standard engineering technical design report for producing a fully compliant finished product
P6 Prepare an industry-standard engineering technical design report **P7** Explain the role of design specifications and standards in the technical design report	**M4** Assess any compliance, safety and risk management issues specific to the technical design report	
LO4 Present to an audience a design solution based on the design report and evaluate the solution/presentation		**D4** Justify potential improvements to the design solution and/or presentation based on reflection and/or feedback
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	**M5** Reflect on the effectiveness of the chosen communication strategy in presenting the design solution	

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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)

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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.

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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

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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

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Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Identify the relevance of mathematical methods to a variety of conceptualised engineering examples		**LO1 & LO2**
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	**M1** Use dimensional analysis to derive equations	**D1** Present data in a method that can be understood by a non-technical audience
LO2 Investigate applications of statistical techniques to interpret, organise and present data		
P4 Summarise data by calculating mean and standard deviation **P5** Calculate probabilities within both binomially distributed and normally distributed random variables	**M2** Interpret the results of a statistical hypothesis test conducted from a given scenario	

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Pass	Merit	Distinction
LO3 Use analytical and computational methods for solving problems by relating sinusoidal wave and vector functions to their respective engineering application		**D2** Model the combination of sine waves graphically and analyse the variation in results between graphical and analytical methods
P6 Solve engineering problems relating to sinusoidal functions **P7** Represent engineering quantities in vector form, and use appropriate methodology to determine engineering parameters	**M3** Use compound angle identities to combine individual sine waves into a single wave	
LO4 Examine how differential and integral calculus can be used to solve engineering problems		**D3** Analyse maxima and minima of increasing and decreasing functions using higher order derivatives
P8 Determine rates of change for algebraic, logarithmic and trigonometric functions **P9** Use integral calculus to solve practical problems relating to engineering	**M4** Formulate predictions of exponential growth and decay models using integration methods	

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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)

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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.

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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

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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

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Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Examine scientific data using both quantitative and qualitative methods		**D1** Analyse scientific data using both quantitative and qualitative methods
P1 Describe SI units and prefix notation **P2** Examine quantitative and qualitative data with appropriate graphical representations	**M1** Explain how the application of scientific method impacts upon different test procedures	
LO2 Determine parameters within mechanical engineering systems		**D2** Compare how changes in the thermal efficiency of a given system can affect its performance.
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	**M2** Determine unknown forces by applying d'Alembert's principle to a free body diagram	

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Pass	Merit	Distinction
LO3 Explore the characteristics and properties of engineering materials		**D3** Compare and contrast theoretical material properties of metals and non-metals with practical test data
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	**M3** Review elastic and electromagnetic hysteresis in different materials	
LO4 Analyse applications of A.C./D.C. circuit theorems, electromagnetic principles and properties		**D4** Evaluate different techniques used to solve problems on a combined series-parallel RLC circuit using A.C. theory.
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.	**M4** Explain the principles and applications of electromagnetic induction	

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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)

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Unit 4: Managing a Professional Engineering Project

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

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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 career progression.

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.

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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 of the 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 identified engineering 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.

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Essential Content

LO1 **Formulate and plan a project that will provide a solution to an identified engineering 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 of Ethical Principles

The National Society for Professional Engineers' Code of Ethics

Regulatory bodies:

Global, European and national influences on engineering and the role of the engineer, in particular: The Royal Academy of Engineering and the UK Engineering Council

The role and responsibilities of the UK Engineering Council and the Professional Engineering Institutions (PEIs)

The content of the UK Standard for Professional Engineering Competence (UKSPEC)

Chartered Engineer, Incorporated Engineer and Engineering Technician

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International regulatory regimes and agreements associated with professional engineering:

European Federation of International Engineering Institutions.

European Engineer (Eur Eng)

European Network for Accreditation of Engineering Education

European Society for Engineering Education

Washington Accord

Dublin Accord

Sydney Accord

International Engineers Alliance

Asia Pacific Economic Cooperation (APEC) Engineers Agreement

LO2 **Conduct planned project activities to generate outcomes which provide a solution to the identified engineering problem**

Project execution phase:

Continually monitoring development against the agreed project plan and adapt the project plan where appropriate

Work plan and time management, using Gantt chart or similar.

Tracking costs and timescales

Maintaining a project diary to monitor progress against milestones and timescales

Engineering professional behaviour sources:

Professional responsibility for health and safety (UK-SPEC)

Professional standards of behaviour (UK-SPEC)

Ethical frameworks:

The Engineering Council and Royal Academy of Engineering's Statement of Ethical Principles

The National Society for Professional Engineers' Code of Ethics

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

Convincing arguments:

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

Critical analysis and evaluation techniques:

Most appropriate evaluation techniques to achieve a potential solution

Secondary and primary data should be critiqued and considered with an objective mindset

Objectivity results in more robust evaluations where an analysis justifies a judgement

LO4 **Present the project report drawing conclusions on the outcomes of the project**

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

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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

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Learning Outcomes and Assessment Criteria

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

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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 in Sustainable 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.

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Unit 8: Mechanical Principles

Unit code	**F/615/1482**
Unit level	**4**
Credit value	**15**

Introduction

Mechanical principles have been crucial for engineers to convert the energy produced by burning oil and gas into systems to propel, steer and stop our automobiles, aircraft and ships, amongst thousands of other applications. The knowledge and application of these mechanical principles is still the essential underpinning science of all machines in use today or being developed into the latest technology.

The aim of this unit is to introduce students to the essential mechanical principles associated with engineering applications.

Topics included in this unit are: behavioural characteristics of static, dynamic and oscillating engineering systems including shear forces, bending moments, torsion, linear and angular acceleration, conservation of energy and vibrating systems; and the movement and transfer of energy by considering parameters of mechanical power transmission systems.

On successful completion of this unit students will be able to explain the underlying principles, requirements and limitations of mechanical systems

Learning Outcomes

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

1. Identify solutions to problems within static mechanical systems.
2. Illustrate the effects that constraints have on the performance of a dynamic mechanical system.
3. Investigate elements of simple mechanical power transmission systems.
4. Analyse natural and damped vibrations within translational and rotational mass-spring systems.

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Essential Content

LO1 Identify solutions to problems within static mechanical systems

Shafts and beams:

The effect of shear forces on beams

Bending moments and stress due to bending in beams

Selection of appropriate beams and columns to satisfy given specifications

The theory of torsion in solid and hollow circular shafts

LO2 Illustrate the effects that constraints have on the performance of a dynamic mechanical system

Energy and work:

The principle of conservation of energy and work-energy transfer in systems

Linear and angular velocity and acceleration

Velocity and acceleration diagrams of planar mechanisms

Gyroscopic motion

LO3 Investigate elements of simple mechanical power transmission systems

Simple systems:

Parameters of simple and compounded geared systems

Efficiency of lead screws and screw jacks

Couplings and energy storage:

Universal couplings and conditions for constant-velocity

Importance of energy storage elements and their applications

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LO4 **Analyse natural and damped vibrations within translational and rotational mass-spring systems**

Types of motion:

Simple harmonic motion

Natural frequency of vibration in mass-spring systems

Damped systems:

Frequency of damped vibrations in mass-spring-damper systems

The conditions for an external force to produce resonance

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Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Identify solutions to problems within static mechanical systems		**D1** Calculate the magnitude of shear force and bending moment in cantilever and encastré beams for a variety of applications
P1 Calculate the distribution of shear force, bending moment and stress due to bending in simply supported beams **P2** Justify the selection of standard rolled steel sections for beams and columns **P3** Determine the distribution of shear stress and the angular deflection due to torsion in solid and hollow circular shafts	**M1** Determine the material of a circular bar from experimental data of angle of twist obtained from a torsion test	
LO2 Illustrate the effects that constraints have on the performance of a dynamic mechanical system		**D2** Calculate solutions of velocities and accelerations within planar mechanisms using trigonometric methodology
P4 Explain the effects of energy transfer in mechanical systems with uniform acceleration present **P5** Identify the magnitude and effect of gyroscopic reaction torque	**M2** Construct diagrams of the vector solutions of velocities and accelerations within planar mechanisms	

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Pass	Merit	Distinction
LO3 Investigate elements of simple mechanical power transmission systems		**D3** Examine the cause of a documented case of mechanical power transmission failure and the steps taken to correct the problem and rectify any design faults
P6 Determine the velocity ratio for compound gear systems and the holding torque required to securely mount a gearbox **P7** Calculate the operating efficiency of lead screws and screw jacks **P8** Explain the conditions required for a constant velocity ratio between two joined shafts	**M3** Examine devices which function to store mechanical energy in their operation	
LO4 Analyse natural and damped vibrations within translational and rotational mass-spring systems		**D4** Identify the conditions needed for mechanical resonance and measures that are taken to prevent this from occurring
P9 Explain the natural frequency of vibration in a mass-spring system	**M4** Determine the amplitude and phase angle of the transient response within a mass-spring damper system	

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Recommended Resources

Textbooks

BIRD, J. and ROSS, C. (2014) *Mechanical Engineering Principles*. 3rd Ed. London: Routledge.

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

Websites

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

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Unit 13: Fundamentals of Thermodynamics and Heat Engines

Unit code	**D/615/1487**
Unit level	**4**
Credit value	**15**

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Introduction

Thermodynamics is one of the most common applications of science in our lives, and it is so much a part of our daily life that it is often taken for granted. For example, when driving your car you know that the fuel you put into the tank is converted into energy to propel the vehicle, and the heat produced by burning gas when cooking will produce steam which can lift the lid of the pan. These are examples of thermodynamics, which is the study of the dynamics and behaviour of energy and its manifestations.

This unit introduces students to the principles and concepts of thermodynamics and its application in modern engineering.

On successful completion of this unit students will be able to investigate fundamental thermodynamic systems and their properties, apply the steady flow energy equation to plant equipment, examine the principles of heat transfer to industrial applications, and determine the performance of internal combustion engines.

Learning Outcomes

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

1. Investigate fundamental thermodynamic systems and their properties.
2. Apply the Steady Flow Energy Equation to plant equipment.
3. Examine the principles of heat transfer to industrial applications.
4. Determine the performance of internal combustion engines.

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Essential Content

LO1 Investigate fundamental thermodynamic systems and their properties

Fundamental systems:

Forms of energy and basic definitions

Definitions of systems (open and closed) and surroundings

First law of thermodynamics

The gas laws: Charles' Law, Boyle's Law, general gas law and the Characteristic Gas Equation

The importance and applications of pressure/volume diagrams and the concept of work done

Polytrophic processes: constant pressure, constant volume, adiabatic and isothermal systems

LO2 Apply the Steady Flow Energy Equation to plant equipment

Energy equations:

Conventions used when describing the behaviour of heat and work

The Non-Flow Energy Equation as it applies to closed systems

Assumptions, applications and examples of practical systems

Steady Flow Energy Equation as applied to open systems

Assumptions made about the conditions around, energy transfer and the calculations for specific plant equipment e.g. boilers, super-heaters, turbines, pumps and condensers

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LO3 **Examine the principles of heat transfer to industrial applications**

Principles of heat transfer:

Modes of heat transmission, including conduction, convection & radiation

Heat transfer through composite walls and use of U and k values

Application of formulae to different types of heat exchangers, including recuperator and evaporative

Regenerators

Heat losses in thick and thin walled pipes, optimum lagging thickness

LO4 **Determine the performance of internal combustion engines**

Performance:

Application of the second law of thermodynamics to heat engines

Comparison of theoretical and practical heat engine cycles, including Otto, Diesel and Carnot

Explanations of practical applications of heat engine cycles, such as compression ignition (CI) and spark ignition engines, including their relative mechanical and thermodynamic efficiencies

Describe possible efficiency improvements to heat engines

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Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Investigate fundamental thermodynamic systems and their properties		**D1** Illustrate the importance of expressions for work done in thermodynamic processes by applying first principles
P1 Describe the operation of thermodynamic systems and their properties **P2** Explain the application of the first law of thermodynamics to appropriate systems **P3** Explain the relationships between system constants for a perfect gas	**M1** Calculate the index of compression in polytrophic processes	
LO2 Apply the Steady Flow Energy Equation to plant equipment		**D2** Produce specific Steady Flow Energy Equations based on stated assumptions in plant equipment
P4 Explain system parameters using the Non-Flow Energy Equation **P5** Apply the Steady Flow Energy Equation to plant equipment	**M2** Derive the Steady Flow Energy Equation from first principles	

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Pass	Merit	Distinction
LO3 Examine the principles of heat transfer to industrial applications		**D3** Distinguish the differences between parallel and counter flow recuperator heat exchangers
P6 Determine the heat transfer through composite walls **P7** Apply heat transfer formulae to heat exchangers	**M3** Explore heat losses through lagged and unlagged pipes	
LO4 Determine the performance of internal combustion engines		**D4** Evaluate the performance of two stroke and four stroke diesel engines
P8 Describe with the aid of a PV (pressure volume) diagram the operational sequence of four stroke spark ignition and four stroke compression ignition engines. **P9** Explain the mechanical efficiency of two and four stroke engines	**M4** Review the relative efficiency of ideal heat engines operating on the Otto and Diesel cycles	

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Recommended Resources

Textbooks

DUNN, D. (2001) *Fundamental Engineering Thermodynamics*. Longman.

EASTOP, T.D. and MCCONKEY, A. (1996) *Applied Thermodynamics for Engineering Technologists*. 5th Ed. Prentice Hall.

EASTOP, T.D. and MCCONKEY, A. (1997) *Applied Thermodynamics for Engineering Technologists Student Solution Manual*. 5th Ed. Prentice Hall.

RAYNER, J. (2008) *Basic Engineering Thermodynamics*. 5th Ed. Pearson.

ROGERS, G.F.C. and MAYHEW, Y.R. (1994) *Thermodynamic and Transport Properties of Fluids: S. I. Units*. 5th Ed. Wiley-Blackwell.

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Unit 34: Research Project

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

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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.

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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.

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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

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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

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Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Conduct the preliminary stages involved in the creation of an engineering research project		**D1** Produce a comprehensive project proposal that evaluates and justifies the rationale for the research
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	**M1** Analyse the project specification and identify any project risks	
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		**D2** Critically analyse literature sources utilised, data analysis conducted and strategies to deal with challenges
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	**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	

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Pass	Merit	Distinction
LO3 Reflect on the impact the research experience could have in enhancing personal or group performance within an engineering context		**D3** Critically evaluate how the research experience enhances personal or group performance within an engineering context
P5 Reflect on the effectiveness and the impact the experience has had upon enhancing personal or group performance	**M4** Evaluate the benefits from the findings of the research conducted	
LO4 Explore the communications approach used for the preparation and presentation of the research project's outcomes		**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
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	**M5** Evaluate how the communication approach meets research project outcomes and objectives	

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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)

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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.**

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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.

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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

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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)

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Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Evaluate the risk evaluation theories and practices associated with the management of projects for the production of current and developing technology		**D1** Specify and analyse the challenges encountered when meeting the requirements for successfully managing engineering activities, and make justified recommendations to overcome these challenges
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	**M1** Critically evaluate the main elements and issues that impact the successful management of engineering activities	
LO2 Produce an engineering services delivery plan that meets the requirements of a sector-specific organisation		**D2** Critically evaluate contingencies that might prevent the delivery plan meeting the requirements of a sector-specific organisation
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	**M2** Evaluate how each step of the delivery plan developed meets the requirements of a sector specific organisation	

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Pass	Merit	Distinction
LO3 Develop effective leadership, individual and group communication skills		**D3** Critically evaluate effective ways for the coaching and mentoring of disillusioned colleagues or of a poorly performing team
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	**M3** Evaluate leadership styles and effective communication skills using specific examples in an organisational context	
LO4 Develop personal commitment to professional standards and obligations to society, the engineering profession and the environment		**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
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	**M4** Summarise the engineering profession ethical standards and patterns of behaviour	

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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)

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Unit 36: Advanced Mechanical Principles

Unit code R/615/1504

Unit level 5

Credit value 15

Introduction

A mechanical engineer is required to have an advanced knowledge of most of the machinery used within the engineering industry, and should understand the physical laws that influence their operation.

The aim of this unit is to continue covering the topics discussed in *Unit 9: Mechanical Principles*. It will provide students with advanced knowledge of the mechanical theories associated with engineering applications.

Topics included in this unit are: Poisson's Ratio and typical values of common materials; the relationship between the elastic constants such as Bulk Modulus, Modulus of Elasticity, Modulus of Rigidity; the relationship between bending moment, slope and deflection in beams; calculating the slope and deflection for loaded beams using Macaulay's method; analysing the stresses in thin-walled pressure vessels; and stresses in thick-walled cylinders, flat and v-section belt drive theory.

On successful completion of this unit students will be able to have more advanced knowledge of mechanical principles to determine the behavioural characteristics of materials subjected to complex loading; assess the strength of loaded beams and pressurised vessels; determine specifications of power transmission system elements; and examine operational constraints of dynamic rotating systems.

Learning Outcomes

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

1. Determine the behavioural characteristics of materials subjected to complex loading.
2. Assess the strength of loaded beams and pressurised vessels.
3. Analyse the specifications of power transmission system elements.
4. Examine operational constraints of dynamic rotating systems.

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Essential Content

LO1 Determine the behavioural characteristics of materials subjected to complex loading

Characteristics of materials:

Definition of Poisson's Ratio and typical values of metals, plastics and composite materials

The relationship between the elastic constants such as Bulk Modulus, Modulus of Elasticity, Modulus of Rigidity and Poisson's Ratio

Characteristics of two-dimensional and three-dimensional loading

Calculation of volumetric strain and volume changes

LO2 Assess the strength of loaded beams and pressurised vessels

Strength:

The relationship between bending moment, slope and deflection in beams

Calculating the slope and deflection for loaded beams using Macaulay's method

Analysing the stresses in thin-walled pressure vessels and stresses in thick-walled cylinders

LO3 Analyse the specifications of power transmission system elements

Specifications:

Flat and v-section belt drive theory

Operation of friction clutches with uniform pressure and uniform wear theories

Principles of both epicyclic and differential gearing, and the torque required to accelerate these systems

Areas of failure when transmitting power mechanically

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LO4 **Examine operational constraints of dynamic rotating systems**

Operational constraints:

Design of both radial plate and cylindrical cams to meet operating specifications

Operating principles of flywheels to store mechanical energy

Balancing of rotating mass systems

The effects of coupling on freely rotating systems

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Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Determine the behavioural characteristics of materials subjected to complex loading		**D1** Critique the behavioural characteristics of materials subjected to complex loading
P1 Discuss the relationship between the elastic constants **P2** Illustrate the effects of two-dimensional and three-dimensional loading on the dimensions of a given material **P3** Determine the volumetric strain and change in volume due to three-dimensional loading	**M1** Assess the effects of volumetric thermal expansion and contraction on isotropic materials	
LO2 Assess the strength of loaded beams and pressurised vessels		**D2** Critique and justify your choice of suitable size universal beam using appropriate computer software to model the application by explaining any assumptions that could affect the selection
P4 Evaluate the variation of slope and deflection along a simply supported beam **P5** Determine the principal stresses that occur in a thin walled cylindrical pressure vessel and a pressurised thick-walled cylinder	**M2** Review a suitable size universal beam from appropriate data tables which conforms to given design specifications for slope and deflection	

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Pass	Merit	Distinction
LO3 Analyse the specifications of power transmission system elements		**D3** Evaluate the conditions needed for an epicyclic gear train to become a differential, and show how a differential works in this application
P6 Discuss the initial tension requirements for the operation of a v-belt drive **P7** Analyse the force requirements to engage a friction clutch in a mechanical system **P8** Analyse the holding torque and power transmitted through epicyclic gear trains	**M3** Critically analyse both the uniform wear and uniform pressure theories of friction clutches for their effectiveness in theoretical calculations	
LO4 Examine operational constraints of dynamic rotating systems		**D4** Critically evaluate and justify the different choices of cam follower that could be selected to achieve a specified motion, explaining the advantages and disadvantages of each application
P9 Explore the profiles of both radial plate and cylindrical cams that will achieve a specified motion **P10** Show the mass of a flywheel needed to keep a machine speed within specified limits **P11** Investigate the balancing masses required to obtain dynamic equilibrium in a rotating system	**M4** Evaluate the effects of misalignment of shafts and the measures that are taken to prevent problems from occurring	

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Recommended Resources

Textbooks

BIRD, J. and ROSS, C. (2014) *Mechanical Engineering Principles*. 3rd Ed. London: Routledge.

KHURMI, R.S. and GUPTA, J.K. (2005) *Textbook of Machine Design*. New Delhi: S. Chand Publishing.

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

Websites

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

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Unit 37: Virtual Engineering

Unit	**Y/615/1505**
Unit level	**5**
Credit value	**15**

Introduction

The work of an engineer increasingly involves the use of powerful software modelling tools (virtual modelling). These tools allow us to predict potential manufacturing difficulties, suggest how a product or component is likely to behave in service, and undertake rapid and low cost design iteration and optimisation, to reduce costs, pre-empt failure and enhance performance.

This unit introduces students to the application of relevant Computer Aided Design (CAD) and analysis engineering tools in contemporary engineering. They will learn about standards, regulations and legal compliance within the context of engineering.

Topics included in this unit are: dimensioning and tolerances, standardisation and regulatory compliance (BS, ASTM, ISO, etc.), material properties and selection, manufacturing processes, 2D, 3D, CAD, solid modelling, one-dimensional and multi-dimensional problems, meshing and boundary conditions, and the finite volume method.

On successful completion of this unit students will be able to consider how to perform computational fluid dynamics (CFD) simulations, develop finite element product and system models, explain the identification of faults in the application of simulation techniques and discuss the modelling method and data accuracy.

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Learning Outcomes

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

1. Explore the capabilities and limitations of computer-based models in meeting design fundamentals and their use in solving problems in engineering.
2. Analyse finite element product and system models in order to find and solve potential structural or performance issues.
3. Perform CFD simulations to evaluate pressure and velocity distributions within an engineering setting.
4. Determine faults in the application of simulation techniques to evaluate the modelling method and data accuracy.

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Essential Content

LO1 **Explore the capabilities and limitations of computer-based models in meeting design fundamentals and their use in solving problems in engineering**

Engineering design fundamentals:

Dimensioning and tolerances

Standardisation and regulatory compliance (BS, ASTM, ISO, etc.)

How to manufacture and what to manufacture:

Material properties and selection

Manufacturing processes: capability, cost issues and selection

Design tools:

2D and 3D CAD

Solid modelling

File types, export and compatibility

Interpretation and presentation of results through a series of guided exercises:

Results obtained, comparison of data, benefits and limitations

Generalisation of provided information, recommendations on current and future applications

LO2 **Analyse finite element product and system models in order to find and solve potential structural or performance issues**

Finite element formulation:

One-dimensional problems

Multi-dimensional problems

Beams

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Finite element method:

Define the problem: simplify an engineering problem into a problem that can be solved using FEA

Define material properties and boundary conditions; choose appropriate functions, formulate equations, solve equations, visualise and explain the results

LO3 **Perform CFD simulations to evaluate pressure and velocity distributions within an engineering setting**

Fundamentals of CFD (Computational Fluid Dynamics):

CFD and the finite volume method background

Meshing and boundary conditions

Applications, advantages and limitations of CFD

CFD simulation and analysis:

Apply CFD to simple design/aerodynamics problems: define the problem, provide initial boundary conditions for the problem, set-up a physical model, define material properties and operating conditions

Interpretation of CFD results

Examine the solution using graphical and numerical tools; suggest and make revision of the models

LO4 **Determine faults in the application of simulation techniques to evaluate the modelling method and data accuracy**

Simulation results:

Extracting relevant information from simulation-based exercises

Interpretation and presentation of results through a series of guided exercises

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Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Explore the capabilities and limitations of computer-based models in meeting design fundamentals and their use in solving problems in engineering		**D1** Critically evaluate and provide supported recommendations for the application of computer-based models to an industrial environment that would improve efficiency and problem-solving
P1 Discuss the benefits and pitfalls of computer based models used within an industrial environment to solve problems in engineering	**M1** Evaluate the capabilities and limitations of computer-based models **M2** Evaluate the processes and applications used in solving problems in engineering	
LO2 Analyse finite element product and system models in order to find and solve potential structural or performance issues		**D2** For a range of practical examples, provide supported and justified recommendations for recognising and solving potential structural or performance-based issues, using finite element product and systems models
P2 Analyse the role of finite element analysis in modelling products and systems **P3** Review a range of practical examples to solve potential structural or performance-based issues using finite element product and systems models	**M3** Critically analyse the finite element product and systems models that help to find and solve potential performance or structural issues for a range of practical examples	

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Pass	Merit	Distinction
LO3 Perform CFD simulations to evaluate pressure and velocity distributions within an engineering setting		**D3** Provide supported and appropriate recommendations for improving efficiency and the generation of suitable meshes for CFD simulations
P4 Demonstrate the importance of CFD simulations applied to evaluate pressure and velocity distributions in the engineering setting **P5** Complete CFD simulation to evaluate pressure and velocity distributions within an engineering setting	**M4** Evaluate the application and limitations of CFD in an engineering context	
LO4 Determine faults in the application of simulation techniques to evaluate the modelling method and data accuracy		**D4** Critically evaluate the appropriate application of simulation techniques that can support decision-making
P6 Determine the faults in the application of simulation techniques **P7** Discuss and evaluate the modelling method and data accuracy	**M5** Extract relevant information from simulation **M6** Trace potential faults in the application of simulation techniques **M7** Critically review results through a series of guided exercises and recommendations	

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Recommended Resources

Textbooks

DATE, A.W. (2005) *Introduction to Computational Fluid Dynamics*. Cambridge University Press.

FISH, J. and BELYTSCHKO, T. (2007) *A First Course in Finite Elements*. Wiley.

TREVOR, H. and BECKER, A.A. (2013) *Finite Element Analysis for Engineers*. A Primer, National Agency for Finite Element Methods & Standards.

Websites

www.tandfonline.com	Taylor & Francis Online International Journal of Computational (Journal)
http://www.inderscience.com/	Inder Science Publishers Progress in Computational Fluid Dynamics, An International Journal (Journal)
https://www.nafems.org/	NAFEMS International Journal of CFD Case Studies (Journal)

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Unit 38: Further Thermodynamics

Unit code	**D/615/1506**
Unit level	**5**
Credit value	**15**

Introduction

From the refrigerators that we use in our homes to the colossal power stations that generate the electricity we use and provide power to industry, the significance that thermodynamics plays in the 21st century cannot be underestimated.

The aim of this unit is to build on the techniques explored in *Unit 13: Fundamentals of Thermodynamics and Heat Engines*, to develop further students' skills in applied thermodynamics by investigating the relationships between theory and practice.

Among the topics included in this unit are: heat pumps and refrigeration, performance of air compressors, steam power plant and gas turbines.

On successful completion of this unit students will be able to determine the performance and operation of heat pumps and refrigeration systems, review the applications and efficiency of industrial compressors, use charts and/or tables to determine steam plant parameters and characteristics, describe the operation of gas turbines and assess their efficiency.

Learning Outcomes

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

1. Evaluate the performance and operation of heat pumps and refrigeration systems.
2. Review the applications and efficiency of industrial compressors.
3. Determine steam plant parameters and characteristics using charts and/or tables.
4. Examine the operation of gas turbines and assess their efficiency.

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Essential Content

LO1 Evaluate the performance and operation of heat pumps and refrigeration systems

Heat pumps and refrigeration:

Reversed heat engines: reversed Carnot and Rankine cycles

Second law of thermodynamics

Refrigeration tables and charts (p-h diagrams)

Coefficient of performance of heat pumps and refrigerators

Refrigerant fluids: properties and environmental effects

Economics of heat pumps

LO2 Review the applications and efficiency of industrial compressors

Performance of air compressors:

Theoretical and realistic cycles

Isothermal and adiabatic work

Volumetric efficiency

Intercoolers, dryers and air receivers

Hazards and faults: safety consideration and associated legislation

LO3 Determine steam plant parameters and characteristics, using charts and/or tables

Steam power plant:

Use of tables and charts to analyse steam cycles

Circuit diagrams showing boiler, super heater, turbine, condenser and feed pump

Theoretical and actual operation: Carnot and Rankine cycle

Efficiencies and improvements

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LO4 **Examine the operation of gas turbines and assess their efficiency**

Gas turbines:

Single and double shaft gas turbine operation

Property diagrams: Brayton (Joule) cycle

Intercooling, reheat and regeneration

Combined heat and power plants

Self-starting and burner ignition continuation

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Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Evaluate the performance and operation of heat pumps and refrigeration systems		**D1** Conduct a cost-benefit analysis on the installation of a ground source heat pump on a smallholding to make valid recommendations for improvements
P1 Using didactic sketches, evaluate the operating principles of both heat pumps and refrigeration systems **P2** Use refrigeration tables and pressure/enthalpy charts to determine COP, heating effect and refrigeration effect of reversed heat engines	**M1** Assess the limiting factors that impact on the economics of heat pumps **M2** Illustrate the contradiction between refrigeration cycles and the second law of thermodynamics	
LO2 Review the applications and efficiency of industrial compressors		**D2** Critically evaluate volumetric efficiency formula for a reciprocating compressor
P3 Assess the different types of industrial compressor and identify justifiable applications for each **P4** Discuss compressor faults and potential hazards **P5** Determine the volumetric efficiency of a reciprocating compressor	**M3** Evaluate isothermal efficiency by calculating the isothermal and polytropic work of a reciprocating compressor	

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Pass	Merit	Distinction
LO3 Determine steam plant parameters and characteristics using charts and/or tables		**D3** Critically evaluate the pragmatic modifications made to the basic Rankine cycle to improve the overall efficiency of steam generation power plants
P6 Discuss the need for superheated steam in a power generating plant **P7** Apply the use of charts and/or tables to establish overall steam plant efficiencies in power systems	**M4** Justify why the Rankine cycle is preferred over the Carnot cycle in steam production plants around the world	
LO4 Examine the operation of gas turbines and assess their efficiency		**D4** Critically analyse the practical solutions manufacturers offer to overcome problematic areas in gas turbines, such as burner ignition continuation and self-starting capabilities
P8 Investigate the principles of operation of a gas turbine plant **P9** Assess the efficiency of a gas turbine system	**M5** Compare and evaluate the actual plant and theoretical efficiencies in a single shaft gas turbine system, accounting for any discrepancies found	

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Recommended Resources

Textbooks

EASTOP, T.D. and MCCONKEY, A. (1996) *Applied Thermodynamics for Engineering Technologists*. 5th Ed. Prentice Hall.

EASTOP, T.D. and MCCONKEY, A. (1996) *Applied Thermodynamics for Engineering Technologists*. Student Solutions Manual. 5th Ed. Prentice Hall.

RAYNER, J. (2008) *Basic Engineering Thermodynamics*. 5th Ed. Pearson.

Websites

http://www.freestudy.co.uk/	Free Study (Tutorials)

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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.

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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.

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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)

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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

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Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Use applications of number theory in practical engineering situations		**D1** Test the correctness of a trigonometric identity using de Moivre's Theorem
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	**M1** Solve problems using de Moivre's Theorem	
LO2 Solve systems of linear equations relevant to engineering applications using matrix methods		**D2** Validate solutions for the given engineering linear equations using appropriate computer software
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	**M2** Determine the solution to a set of given engineering linear equations using the Inverse Matrix Method for a 3x3 matrix	

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Pass	Merit	Distinction
LO3 Approximate solutions of contextualised examples with graphical and numerical methods		**D3** Critically evaluate the use of numerical estimation methods, commenting on their applicability and the accuracy of the methods
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	**M3** Solve engineering problems and formulate mathematical models using graphical and numerical integration	
LO4 Review models of engineering systems using ordinary differential equations		**D4** Critically evaluate first and second-order differential equations when generating the solutions to engineering situations using models of engineering systems
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	**M4** Demonstrate how different models of engineering systems using first-order differential equations can be used to solve engineering problems	

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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)

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Electives

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Unit 11: Fluid Mechanics

Unit code R/615/1485

Unit level 4

Credit value 15

Introduction

Fluid mechanics is an important subject to engineers of many disciplines, not just those working directly with fluid systems. Mechanical engineers need to understand the principles of hydraulic devices and turbines (wind and water); aeronautical engineers use these concepts to understand flight, while civil engineers concentrate on water supply, sewerage and irrigation.

This unit introduces students to the fluid mechanics techniques used in mechanical engineering. The hydraulic devices and systems that incorporate the transmission of hydraulic pressure and forces exerted by a static fluid on immersed surfaces.

Topics included in this unit are: pressure and force, submerged surfaces, fluid flow theory, aerodynamics, and hydraulic machinery.

On successful completion of this unit students will be able to work with the concept and measurement of viscosity in fluids, and the characteristics of Newtonian and non-Newtonian fluids; examine fluid flow phenomena, including energy conservation, estimation of head loss in pipes and viscous drag; and examine the operational characteristics of hydraulic machines, in particular the operating principles of various water turbines and pumps.

Learning Outcomes

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

1. Determine the behavioural characteristics of static fluid systems.
2. Examine the operating principles and limitations of viscosity measuring devices.
3. Investigate dynamic fluid parameters of real fluid flow.
4. Explore dynamic fluid parameters of real fluid flow.

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Essential Content

LO1 Determine the behavioural characteristics of static fluid systems

Pressure and force:

How Pascal's laws define hydrostatic pressure

Pressure with the use of manometers

Transmission of force in hydraulic devices

Submerged surfaces:

Determining thrust on immersed surfaces

Moments of area and parallel axis theorem

Calculating centre of pressure with moments of area

LO2 Examine the operating principles and limitations of viscosity measuring devices

Viscosity in fluids:

Dynamic and kinematic viscosity definitions

Characteristics of Newtonian fluids

Effects of temperature on viscosity

Classification of non-Newtonian fluids

Operating principles and limitations:

Operating principles of viscometers

Converting results acquired from viscometers into viscosity values

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LO3 Investigate dynamic fluid parameters of real fluid flow

Fluid flow theory:

Energy present within a flowing fluid and the formulation of Bernoulli's Equation

Classification of fluid flow using Reynolds numbers

Calculations of flow within pipelines

Head losses that occur within a fluid flowing in a pipeline

Viscous drag resulting from fluid flow and the formulation of the drag equation

Aerodynamics:

Application of prior theory of fluid flow to aerodynamics

Principles of aerofoils and how drag induces lift

Flow measuring devices and their operating principles

LO4 Explore the operating principles and efficiencies of hydraulic machines

Hydraulic machinery:

Operating principles of different types of water turbine

Reciprocating and centrifugal pump theory

Efficiencies of these different types of hydraulic machinery

Environmental concerns surrounding hydraulic machines

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Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Determine behavioural characteristics of static fluid systems		**D1** Explain the use and limitations of manometers to measure pressure
P1 Describe force and centre of pressure on submerged surfaces **P2** Carry out appropriate calculations on force and centre of pressure on submerged surfaces	**M1** Determine the parameters of hydraulic devices that are used in the transmission of force	
LO2 Examine the operating principles and limitations of viscosity measuring devices		**D2** Illustrate the resultsof a viscosity test on a Newtonian fluid at various temperatures with that which is givenon a data sheet and explain discrepancies.
P3 Explain the operation and constraints of differentviscometers that quantify viscosity in fluids **P4** Carry out appropriate calculations on the effect of changes in temperature and other constraints on the viscosity of a fluid	**M2** Explain, with examples, the effects of temperature and shear forces on Newtonian and non-Newtonian fluids	

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Pass	Merit	Distinction
LO3 Investigate dynamic fluid parameters of real fluid flow		**D3** Determine the head losses accumulated by a fluid when flowing in a pipeline for various applications
P5 Determine parameters of a flowing fluid using Bernoulli's Equation **P6** Define the flow of a fluidusing Reynold's numbers and the significance of this information	**M3** Explain the effect of aerodynamic drag and lift on aerofoils	
LO4 Explore the operating principles and efficiencies of hydraulic machines		**D4** Describe and analyse the arguments concerning the ecological impact of hydroelectric power.
P7 Determine the efficiency of a water turbine **P8** Calculate the input power requirements ofcentrifugal pumps	**M4** Identify the limitationsthat exist within different types of water turbine	

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Recommended Resources

Textbook

MASSEY, B.S. and WARD-SMITH, J. (2011) *Mechanics of Fluids*. 9th Ed. Oxford: Spon Press.

Journals

Journal of Fluid Mechanics. Cambridge University Press.

Annual Review of Fluid Mechanics. Annual Reviews, California.

Websites

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

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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.

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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.

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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

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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

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Learning Outcomes and Assessment Criteria

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

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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	

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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.

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Unit 48: Manufacturing Systems Engineering

Unit code J/615/1516

Unit level 5

Credit value 15

Introduction

Manufacturing systems engineering is concerned with the design and on-going operation and enhancement of the integrated elements within a manufacturing system, which is a very complex activity, even for simple products. The art of manufacturing systems engineering is essentially designing systems that can cope with that complexity effectively.

The aim of this unit is to develop students' understanding of that complexity within a modern manufacturing environment. Among the topics covered in this unit are: elements that make up a manufacturing system, including production engineering, plant and maintenance engineering, product design, logistics, production planning and control, forecast quality assurance, accounting and purchasing, all of which work together within the manufacturing system to create products that meet customers' requirements.

On successful completion of this unit students will be able to explain the principles of a manufacturing system and consider how to design improvements. They will be introduced to all the elements that make up a modern manufacturing system, and they will learn how to optimise the operation of existing systems through discerning use of monitoring data. Some of the elements will be developed in greater depth; of particular importance will be looking at the systems of production planning and control, which are the day-to-day tools used to manage the manufacturing system effectively.

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Learning Outcomes

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

1. Illustrate the principles of manufacturing systems engineering and explain their relevance to the design and enhancement of manufacturing systems.
2. Use a range of analysis tools, including value stream mapping, to determine the effectiveness and efficiency of a manufacturing system, and then develop an appropriate future state for that system.
3. Outline the impact of different production planning approaches on the effectiveness of a manufacturing system.
4. Define the responsibilities of manufacturing systems engineering and review how they enable successful organisations to remain competitive.

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Essential Content

LO1 **Illustrate the principles of manufacturing systems engineering and their relevance to the design and enhancement of manufacturing systems**

Manufacturing systems elements:

Elements to be considered include quality, cost, delivery performance and optimising output

Problem-solving and managing complexity, maintenance scheduling and planning, resource planning and productivity

Effect of testing and data analysis on performance

LO2 **Use a range of analysis tools, including value stream mapping, to determine the effectiveness and efficiency of a manufacturing system, and then develop an appropriate future state for that system**

Analysis tools:

Introduction to value stream mapping, and the value of both current state mapping and future state mapping

Bottle-neck analysis, by using process improvement tools and techniques e.g. value stream analysis, simulation, kanban

Using key performance indicators to understand the performance of a manufacturing system e.g. overall equipment effectiveness, lead-time, cycle time, waiting time, yield, delivery performance, safety metrics

Reviewing key performance indicators; methods for presenting metrics and performance e.g. balanced scorecards, performance dashboards, Andon boards, Gemba walks

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LO3 Outline the impact of different production planning approaches on the effectiveness of a manufacturing system

Production planning approaches:

Examples of production planning strategy: push vs pull factors, kanban systems, make to stock, make to order and engineer to order

Production planning approaches such as batch and queue, pull/kanban, just-in-time, modular design, configuration at the final point, and master scheduling

Production planning management tools:

Enterprise Resource Mapping (ERP) systems, Material Resource Planning (MRP 2) and Manufacturing Execution systems, ability to managing complexity and resourcing through information technology

Industrial engineering issues: the importance of standard times and the impact on productivity and the costing of products. Standard work underpins the repeatability of process and quality control

LO4 Review the functions of manufacturing systems engineering and how they enable successful organisations to remain competitive

Effectiveness of manufacturing systems:

Plant layout design, planning and control, productivity and continuous improvement, quality control and equipment effectiveness

Return on investment and capital expenditure, control of the cost of planned maintenance

Manufacturing information technology: the supply of data from the process to decision-makers e.g. failure modes for both product and system, maintenance and down time data, standard times for production, material control, energy usage

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Learning Outcomes and Assessment Criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Illustrate the principles of manufacturing systems engineering and their relevance to the design and enhancement of manufacturing systems</td><td rowspan="2">D1 Apply value stream mapping to a production process to evaluate the efficiency of that process by using the current state map to suggest improvements</td></tr>
<tr><td>P1 Illustrate the principles of manufacturing engineering

P2 Explain the relevance of manufacturing systems engineering to the design of a manufacturing system</td><td>M1 Evaluate the impact that manufacturing systems have on the success of a manufacturing organisation</td></tr>
<tr><td colspan="2">LO2 Use a range of analysis tools, including value stream mapping, to determine the effectiveness and efficiency of a manufacturing system, and then develop an appropriate future state for that system</td><td rowspan="2">D2 Review value stream mapping against other production planning methodologies and justify its use as a production planning tool</td></tr>
<tr><td>P3 Apply value stream mapping to visualise a production process</td><td>M2 Identify optimisation opportunities through value stream mapping of a production process</td></tr>
</table>

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Pass	Merit	Distinction
LO3 Outline the impact of different production planning approaches on the effectiveness of a manufacturing system		**D3** Justify the most appropriate production planning technique and its suitability for a particular manufacturing approach, such as make to stock, make to order, or engineer to order
P4 Identify the common production planning approaches and state their impact on manufacturing systems **P5** Define the types of manufacturing approach, such as make to stock, make to order and engineer to order	**M3** Evaluate the effectiveness of production planning methods **M4** Explore the effectiveness of common production planning techniques to identify which production approach they complement	
LO4 Review the functions of manufacturing systems engineering and how they enable successful organisations to remain competitive		**D4** Critically consider the elements of an existing manufacturing system to appraise why this is successful
P6 Define the core responsibilities of a manufacturing systems engineer **P7** Identify the key contributing success factors of a manufacturing system	**M5** Evaluate the impact that a manufacturing systems engineering has on successful manufacturing organisations	

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Recommended Resources

Textbooks

BICHENO, J. and HOLWEG, M. (2009) *The Lean Toolbox*. 4th Ed. PICSIE Books.

CHOPRA, S. and MEINDL, P. (2015) *Supply Chain Management: Strategy, Planning, and Operation (Global Edition)*. 6th Ed. Pearson.

SLACK, N. (2013) *Operations Management*. 7th Ed. Pearson.

WOMACK, J., JONES, D. and ROOS, D. (1990) *The Machine That Changed the World*. Free Press.

Websites

http://www.industryweek.com/ — Industry Week
Five Benefits of an MES
(Article)

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Unit 50: Advanced Manufacturing Technology

Unit code R/615/1518

Unit level 5

Credit value 15

Introduction

The ability of successful companies to meet the growing demand of customers is heavily influenced by the development of advanced manufacturing technologies. Customers expect high complexity products, on demand, and with a growing element of customisation. In adopting advanced manufacturing technologies, successful companies will ensure faster time to market of new products, improve products and processes, use new, sustainable, materials, and customise to customer requirements. Manufacturing systems engineering underpins this development.

In order to meet changing customer expectations and gain competitive advantage, focus needs to be applied to developing smart factories and advanced manufacturing technologies. Manufacturing organisations will seek integration between manufacturing technology, high performance computing, the internet, and the product at all stages of its life cycle.

Industry 4.0 is the term that has been adopted to describe the 'fourth' industrial revolution currently underway, at present, in the manufacturing and commercial sectors of our society. It is a revolution based on the integration of cyber-physical systems with the Internet of Things and services. For the manufacturing sector, this integration has been enabled by successfully combining high performance computing, the internet and the development of advanced manufacturing technologies. Industry 4.0 is changing the way the world's most successful companies produce the products that their global customers demand.

On successful completion of this unit students will be able to analyse and evaluate the potential of using advanced manufacturing technologies to improve the competitive advantage of the organisations adopting them. The student will develop knowledge and understanding of advanced manufacturing technologies, digitalisation and a range of advanced manufacturing technologies. They will also develop their own research activities into the latest developments.

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Learning Outcomes

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

1. Recognise a range of advanced manufacturing processes and cite examples of where they are most effective.
2. Analyse advanced manufacturing technologies to determine their appropriateness for an application or process.
3. Analyse an existing manufactured product and associated process to introduce proposals for possible improvements based on the introduction of advanced manufacturing technologies.
4. Evaluate the concept of the next industrial revolution to determine the impact onboth manufacturers and the consumer.

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Essential Content

LO1 Recognise a range of advanced manufacturing processes to cite examples of where they are most effective

Manufacturing processes:

Pressing and forming, casting and moulding, joining and soldering, mixing, final assembly, packaging, material handling, quality control/inspection

Advanced manufacturing processes:

Additive manufacturing technology (e.g. replacing forming, moulding, pressing), 3D printing, impact on rapid prototyping, availability of spares/obsolete parts, medical components available and customised

Mass customisation through 3D printing, opening up a self-serve market

Robotics/human interface and automation, high-precision technology and productivity e.g. aerospace, automotive, electronics assembly

Types of application or industry:

Industry examples: aerospace, automotive, healthcare, electronics, food and beverage, chemical and pharmaceutical, minerals, oil and gas, retail, fashion

Application examples: assembly, joining, moulding, soldering

LO2 Analyse advanced manufacturing technologies to determine their appropriateness for an application or process

Manufacturing technologies:

High precision robotics and automation: healthcare (components and processes), aerospace, automotive, process control and visualisation through automation technology

Improvement in productivity through greater automation

Quality of manufacturing processes improved through integration of robotics

Examples of using 3D printing and other forms of additive manufacturing to produce medical equipment, spares parts for items that may have become obsolete, mass customisation; what the customer wants, when they want it

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LO3 Analyse an existing manufactured product and associated process to introduce proposals for possible improvements based on the introductionof advanced manufacturing technologies

Manufactured product:

Research the traditional methods used to manufacture an existing product, determine the associated processes required to bring it to market and identify the limitations of these methods and processes

Explore how advanced manufacturing technology could be applied to produce this product and suggest how applying such processes would influence its production, costs, time to market and customer satisfaction (e.g. healthcare/medical such as hip joint, traditional method vs mass customisation and the possible use of 3D printing)

3D printing and its availability is opening up new markets, but also new business models for organisations; explore the future possibilities for self-serve/or self-production of items

LO4 Evaluate the concept of the next industrial revolution to determine theimpact on both manufacturers and the consumer

Next industrial revolution:

Industry 4.0

Internet of Things: over time industry has transformed from being local-based to communication-based technology; the possibilities for connected technology and connected factories are ever increasing

Cyber-physical systems: collaborative robotics and highly integrated manufacturing systems

Mass customisation: there is a growing demand and desire for individual products. In 1908, referring to the Model T, Henry Ford said, "You can have any colour, as long as it's black." In 2015 you can have trillions of variations of the Ford F150; advanced manufacturing technology and the ability to manage complexity is key to that realisation

Digitalisation and increased automation; the ability to simulate and create a digital twin has the potential to dramatically reduce time to market

The drive to increase efficiency requires innovation and innovative technology; 25% of all energy used is required by industry alone

Big data; the development of an ever connected production environment alongside cloud computing presents a challenge of having a stream of production data and the need to analyse this in order to make timely informeddecisions

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Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Recognise a range of advanced manufacturing processes to cite examples of where they are most effective		**D1** Research and evaluate a manufactured product and identify the technology used
P1 Recognise a range of advanced manufacturing process or technologies and cite examples of where they are most effective	**M1** Compare a traditional manufacturerto one employing advanced manufacturingto discuss the fundamental differences	
LO2 Analyse advanced manufacturing technologies to determine their appropriateness for an application or process		**D2** Examine the potential justification for an organisation to invest in advanced manufacturing technology
P2 Analyse advanced manufacturing technologies to determine their appropriateness for an application or process	**M2** Explore how advanced manufacturing could be applied, and give examples of where technology would be suited	
LO3 Analyse an existing manufactured product and associated process to introduce proposals for possible improvements based on the introduction of advanced manufacturing technologies		**D3** Critically evaluate the impact of utilising advanced manufacturing technology rather than the existing method on both the customer and the manufacturer
P3 Analyse an existing manufactured product and identify the key technology used to produce the item	**M3** Evaluate the effectiveness of the current method and suggest an alternative advanced manufacturing technology	

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Pass	Merit	Distinction
LO4 Evaluate the concept of the next industrialrevolution to determine the impact on both manufacturers and the consumer		**D4** Investigate and justifythe types of industry or product that would benefit most from an innovative advanced manufacturing approach
P4 Evaluate the concept of a 4th industrial revolution **P5** Identify the key elements of Industry 4.0	**M4** Evaluate the impact of advanced manufacturing on bothmanufacturers and the customer	

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Recommended Resources

Textbooks

LEFTERI, C. (2012) *Making It: Manufacturing Techniques for Product Design*. 2nd Ed. Laurence King.

WRIGHT, P.K. (2000) *21st Century Manufacturing. New Jersey*: Prentice-Hall Inc.

Websites

https://www.gov.uk	GOV.UK Future of manufacturing: a new era of opportunityand challenge for the UK (Report)
https://w3.siemens.com/	Siemens The Future of Manufacturing (General Reference)
https://hvm.catapult.org.uk/	Catapult High Value Manufacturing(General Reference)

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