BTEC

Pearson Higher National

Engineering

(General Engineering)

Level 4

BTEC Higher National Certificate

Pearson

Year 1 (Level 4)

HNC Engineering (General Engineering) or (Electrical and Electronic Engineering)

60 Credits

Core Unit - Mandatory

Unit 2	Engineering Maths	15 Credits

Optional

Unit 12	Engineering Management	15 Credits
Unit 9	Materials, Properties and Testing	15 Credits
Unit 23	Computer Aided Design and Manufacture	15 Credits

Year 2 (Level 4)

HNC Engineering (General Engineering) or (Electrical and Electronic Engineering)

60 Credits (120 in total)

Core Unit - Mandatory

Unit 1	Engineering Design	15 Credits
Unit 3	Engineering Science	15 Credits
Unit 4	Managing a Professional Engineering Project (Pearson Set)	15 Credits

Optional

Unit 6	Mechatronics	15 Credits

Unit 1: Engineering Design

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

Introduction

The tremendous possibilities of the techniques and processes developed by engineers can only be realised by great design. Design turns an idea into a useful artefact, the problem into a solution, or something ugly and inefficient into an elegant, desirable and cost effective everyday object. Without a sound understanding of the design process the engineer works in isolation without the links between theory and the needs of the end user.

The aim of this unit is to introduce students to the methodical steps that engineers use in creating functional products and processes; from a design brief to the work, and the stages involved in identifying and justifying a solution to a given engineering need.

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

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

Learning Outcomes

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

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

Essential Content

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

Planning techniques used to prepare a design specification:

Definition of client's/users objectives, needs and constraints

Definition of design constraints, function, specification, milestones

Planning the design task: Flow charts, Gantt charts, network and critical path analysis necessary in the design process

Use of relevant technical/engineering/industry standards within the design process

Design process:

Process development, steps to consider from start to finish

The cycle from design to manufacture

Three- and five-stage design process

Vocabulary used in engineering design

Stage of the design process which includes:

Analysing the situation, problem statement, define tasks and outputs, create the design concept, research the problem and write a specification

Suggest possible solutions, select a preferred solution, prepare working drawings, construct a prototype, test and evaluate the design against objectives, design communication (write a report)

Customer/stakeholder requirements:

Converting customer request to a list of objectives and constraints

Interpretation of design requirements

Market analysis of existing products and competitors

Aspects of innovation and performance management in decision-making

LO2 **Formulate possible technical solutions to address the student-prepared design specification**

Conceptual design and evaluating possible solutions:

Modelling, prototyping and simulation using industry standard software, (e.g. AutoCAD, Catia, SolidWorks, Creo) on high specification computers

Use of evaluation and analytical tools, e.g. cause and effect diagrams, CAD, knowledge-based engineering

LO3 **Prepare an industry-standard engineering technical design report**

Managing the design process:

Recognising limitations including cost, physical processes, availability of material/components and skills, timing and scheduling

Working to specifications and standards, including:

The role of compliance checking, feasibility assessment and commercial viability of product design through testing and validation

Design for testing, including:

Material selection to suit selected processes and technologies

Consideration of manufacturability, reliability, life cycle and environmental issues

The importance of safety, risk management and ergonomics

Conceptual design and effective tools:

Technologies and manufacturing processes used in order to transfer engineering designs into finished products

LO4 **Present to an audience a design solution based on the design report and evaluate the solution/presentation**

Communication and post-presentation review:

Selection of presentation tools

Analysis of presentation feedback

Strategies for improvement based on feedback

Learning Outcomes and Assessment Criteria

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 possible design solution	**M3** Apply the principles of modelling/ simulation/prototyping, using appropriate software, to develop appropriate design solutions	
LO3 Prepare an industry-standard engineering technical design report		**D3** Evaluate the effectiveness of the presented industry-standard engineering technical design report for producing a fully compliant finished product
P6 Prepare an industry-standard engineering technical design report **P7** Assess the presented technical design and identify any potential limitations it may have	**M4** Explain the role of design specifications and standards in producing a finished product **M5** Identify any compliance, safety and risk management issues present in the chosen solution	

Pass	Merit	Distinction
LO4 Present to an audience a design solution based on the design report and evaluate the solution/presentation		**D4** Justify potential improvements to the presented design solution, based on reflection and/or feedback obtained from the presentation
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	**M6** Reflect on effectiveness of communication strategy in presenting the solution	

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)

Links

This unit links to the following related units:

Unit 23: Computer Aided Design and Manufacture (CAD/CAM)

Unit 34: Research Project

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 by using appropriate computer software packages.
3. Use analytical and computational methods for solving problems by relating sinusoidal wave and vector functions to their respective engineering applications.
4. Examine how differential and integral calculus can be used to solve engineering problems.

Essential Content

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

Mathematical concepts:

Dimensional analysis

Arithmetic and geometric progressions

Functions:

Exponential, logarithmic, circular and hyperbolic functions

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

Summary of data:

Mean and standard deviation of grouped data

Pearson's correlation coefficient

Linear regression

Probability theory:

Binomial and normal distribution

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

Sinusoidal waves:

Sine waves and their applications

Trigonometric and hyperbolic identities

Vector functions:

Vector notation and properties

Representing quantities in vector form

Vectors in three dimensions

LO4 **Examine how differential and integral calculus can be used to solve engineering problems**

Differential calculus:

Definitions and concepts

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

Differentiation of functions

Differentiation of functions including:

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

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

Integral calculus:

Definite and indefinite integration

Integrating to determine area

Integration of common/standard functions and by substitution and parts

Exponential growth and decay

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

Engineering problems involving calculus:

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

Learning Outcomes and Assessment Criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Identify the relevance of mathematical methods to a variety of conceptualised engineering examples</td><td rowspan="5">LO1 & 2
D1 Present statistical data in a method that can be understood by a non-technical audience</td></tr>
<tr><td>P1 Apply dimensional analysis techniques to solve complex problems
P2 Generate answers from contextualised arithmetic and geometric progressions
P3 Determine solutions of equations using exponential, trigonometric and hyperbolic functions</td><td>M1 Use dimensional analysis to derive equations</td></tr>
<tr><td colspan="2">LO2 Investigate applications of statistical techniques to interpret, organise and present data by using appropriate computer software packages</td></tr>
<tr><td>P4 Summarise data by calculating mean and standard deviation, and simplify data into graphical form
P5 Calculate probabilities within both binomially distributed and normally distributed random variables</td><td>M2 Interpret the results of a statistical hypothesis test conducted from a given scenario</td></tr>
<tr><td colspan="2">LO3 Use analytical and computational methods for solving problems by relating sinusoidal wave and vector functions to their respective engineering application</td><td rowspan="2">D2 Model the combination of sine waves graphically and analyse the variation in results between graphical and analytical methods</td></tr>
<tr><td>P6 Solve engineering problems relating to sinusoidal functions
P7 Represent engineering quantities in vector form, and use appropriate methodology to determine engineering parameters</td><td>M3 Use compound angle identities to separate waves into distinct component waves</td></tr>
</table>

Pass	Merit	Distinction
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 circular functions **P9** Use integral calculus to solve practical problems relating to engineering	**M4** Formulate predictions of exponential growth and decay models using integration methods	

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)

Links

This unit links to the following related units:

Unit 39: Further Mathematics

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 computational methods.
2. Determine parameters within mechanical engineering systems.
3. Explore the characteristics and properties of engineering materials.
4. Analyse applications of A.C./D.C. circuit theorems, electromagnetic principles and properties.

Essential Content

LO1 **Examine scientific data using both quantitative and computational methods**

International system of units:

The basic dimensions in the physical world and the corresponding SI base units

SI derived units with special names and symbols

SI prefixes and their representation with engineering notation

Interpreting data:

Investigation using the scientific method to gather appropriate data

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 objects subjected to concentrated and distributed loads

Newton's laws of motion, D'Alembert's principle and the principle of conservation of energy

Fluid mechanics and thermodynamics:

Archimedes' principle and hydrostatics

Continuity of volume and mass flow for an incompressible fluid

Effects of sensible/latent heat of fluid

Heat transfer due to temperature change and the thermodynamic process equations

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

Material properties:

Atomic structure of materials and the structure of metals, plastics and composites

Mechanical and electromagnetic properties of materials

Material failure:

Destructive and non-destructive testing of materials

The effects of gradual and impact loading on a material.

Degradation of materials and hysteresis

LO4 **Analyse applications of A.C./D.C. circuit theorems, electromagnetic principles and properties**

D.C. circuit theory:

Voltage, current and resistance in D.C. networks

Exploring circuit theorems (Thevenin, Norton, Superposition), Ohm's law and Kirchhoff's voltage and current laws

A.C. circuit theory:

Waveform characteristics in a single-phase A.C. circuit

RLC circuits

Magnetism:

Characteristics of magnetic fields and electromagnetic force

The principles and applications of electromagnetic induction

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Examine scientific data using both quantitative and computational methods		**D1** Present an analysis of scientific data using both computational 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** Critically compare how changes in the thermal efficiency of a heat transfer process can affect the behavioural characteristics of a mechanical systems
P3 Determine the support reactions of a beam carrying a concentrated load and a uniformly distributed load **P4** Use Archimedes' principle in contextual engineering applications **P5** Determine through practical examples the change within a solid material when exposed to temperature variations	**M2** Determine unknown forces by applying d'Alembert's principle to a free body diagram	
LO3 Explore the characteristics and properties of engineering materials		**D3** Compare and contrast theoretical material properties of metal and non-metallic materials compared with values obtained through destructive and non-destructive test methods
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, electrical and magnetic hysteresis in different materials	

Pass	Merit	Distinction
LO4 Analyse applications of A.C./D.C. circuit theorems, electromagnetic principles and properties		**D4** Critically evaluate different techniques used to solve problems on series-parallel R, L, C circuits using A.C. theory.
P8 Calculate currents and voltages in circuits using circuit theorems. **P9** Describe how complex waves are produced from sinusoidal waveforms. **P10** Solve problems on series R, L, C circuits with A.C. theory.	**M4** Explain the principles and applications of electromagnetic induction.	

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)

Links

This unit links to the following related units:

Unit 9: Materials, Properties and Testing

Unit 3: Engineering Science

Unit 4: Managing a Professional Engineering Project

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

Introduction

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

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 assignment. 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.

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

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

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

The cycle of reflection:

To include reflection in action and reflection on action

How to use reflection to inform future behaviour, particularly directed towards sustainable performance

The importance of Continuing Professional Development (CPD) in refining on-going professional practice

Reflective writing:

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

Learning Outcomes and Assessment Criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Formulate and plan a project that will provide a solution to an identified engineering problem</td><td rowspan="2">D1 Illustrate the effect of legislation and ethics in developing the project plan</td></tr>
<tr><td>P1 Select an appropriate engineering based project, giving reasons for the selection

P2 Create a project plan for the engineering project</td><td>M1 Undertake a feasibility study to justify project selection</td></tr>
<tr><td colspan="2">LO2 Conduct planned project activities to generate outcomes which provide a solution to the identified engineering problem</td><td rowspan="2">D2 Critically evaluate the success of the project plan making recommendations for improvements</td></tr>
<tr><td>P3 Conduct project activities, recording progress against original project plan</td><td>M2 Explore alternative methods to monitor and meet project milestones, justify selection of chosen method(s)</td></tr>
<tr><td colspan="2">LO3 Produce a project report analysing the outcomes of each of the project processes and stages</td><td rowspan="4">LO3 & LO4

D3 Critically analyse the project outcomes making recommendations for further development</td></tr>
<tr><td>P4 Produce a project report covering each stage of the project and analysing project outcomes</td><td>M3 Use appropriate critical analysis and evaluation techniques to analyse project findings</td></tr>
<tr><td colspan="2">LO4 Present the project report drawing conclusions on the outcomes of the project</td></tr>
<tr><td>P5 Present the project report using appropriate media to an audience</td><td>M4 Analyse own behaviours and performance during the project and suggest areas for improvement</td></tr>
</table>

Recommended Resources

Textbooks

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

STRIEBIG, B., OGUNDIPE, A. and PAPADAKIS, M. (2015) *Engineering Applications 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.

Links

This unit links to the following related units:

Unit 34: Research Project

Unit 35: Professional Engineering Management

Unit 6: Mechatronics

Unit code **T/615/1480**

Unit level **4**

Credit value **15**

Introduction

Auto-focus cameras, car cruise control and automated airport baggage handling systems are examples of mechatronic systems. Mechatronics is the combination of mechanical, electrical and computer/controlled engineering working together in automated systems and 'smart' product design.

Among the topics included in this unit are: consideration of component compatibility, constraints on size and cost, control devices used, British and/or European standards relevant to application, sensor types and interfacing, simulation and modelling software functions, system function and operation, advantages and disadvantages of software simulation, component data sheets, systems drawings, flowcharts, wiring and schematic diagrams.

On successful completion of this unit students will be able to explain the basic mechatronic system components and functions, design a simple mechatronic system specification for a given application, use appropriate simulation and modelling software to examine its operation and function, and solve faults on mechatronic systems using a range of techniques and methods.

Learning Outcomes

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

1. Explain the design and operational characteristics of a mechatronic system.
2. Design a mechatronic system specification for a given application.
3. Examine the operation and function of a mechatronics system using simulation and modelling software.
4. Identify and correct faults in a mechatronic system.

Essential Content

LO1 **Examine the design and operational characteristics of a mechatronic system**

Origins and evolution:

History and early development, evolution

Practical examples and extent of use

Current operational abilities and anticipated improvements

Systems characteristics:

Design of systems in an integrated way

Sensor and transducer types used

Consideration of component compatibility

Constraints on size and cost

Control device requirements and examples of applications

LO2 **Design a mechatronic system specification for a given application**

Systems specifications:

British and/or European standards relevant to application

Sensor types and interfacing

Actuator technology availability and selection

Selection and use of appropriate control software/devices.

Consideration of the interaction of system variables

System commissioning parameters

LO3 **Examine the operation and function of a mechatronics system using simulation and modelling software**

Operation and functions:

Simulation and modelling software functions

System function and operation

Modes of operation simulation, loading and surges

Advantages and disadvantage of software simulation

LO4 **Identify and correct faults in a mechatronic system**

Locating and correcting system faults:

Component data sheets, systems drawings, flowcharts, wiring and schematic diagrams

Original system correct function and operation

Inspection and testing using methodical fault location techniques and methods, use of control software to aid fault location

Identification, evaluation and verification of faults and their causes, rectification, final system testing and return to service

Learning Outcomes and Assessment Criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Examine the design and operational characteristics of a mechatronic system</td><td rowspan="2">D1 Investigate an actual mechatronics system specification to propose alternative solutions</td></tr>
<tr><td>P1 Describe the key components of a given mechatronics system
P2 Identify the types of actuators, sensors and transducers used in the mechatronics system</td><td>M1 Explore how the mechatronics components operate as part of an integrated system
M2 Investigate the methods of control used by mechatronics systems</td></tr>
<tr><td colspan="2">LO2 Design a mechatronic system specification for a given application</td><td rowspan="2">D2 Evaluate the operational capabilities and limitations of the mechatronics system design specification produced</td></tr>
<tr><td>P3 Select the relevant sensor and the appropriate actuator technologies and produce a design specification suitable for these selections</td><td>M3 Justify the sensor and actuator technologies selected with reference to available alternatives</td></tr>
<tr><td colspan="2">LO3 Examine the operation and function of a mechatronics system using simulation and modelling software</td><td rowspan="2">D3 Explain the function and operation of a simulated mechatronics system</td></tr>
<tr><td>P4 Demonstrate industry standard mechatronics simulation/modelling software</td><td>M4 Describe the advantages and disadvantages of the software simulation</td></tr>
<tr><td colspan="2">LO4 Identify and correct faults in a mechatronic system</td><td rowspan="2">D4 Investigate the causes of faults on a mechatronics system and suggest alternatives to the design specification to improve reliability</td></tr>
<tr><td>P5 Explain the safe use of fault finding test equipment
P6 Locate and rectify faults on a mechatronic system</td><td>M5 Apply and document the correct use of fault finding techniques/methods</td></tr>
</table>

Recommended Resources

Textbooks

BOLTON, W. (2015) *Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering*. 5th Ed. Essex: Pearson Education Limited.

MAHALIK, N.P. (2010) *Mechatronics: Principles, Concepts and Applications*. New Delhi: McGraw-Hill.

ONWUBOLU, G.C. (2005) *Mechatronics: Principles and Applications*. Oxford: Elsevier.

RAMACHANDRAN, K.P., VIJAYARAGHAVAN, G.K. and BALASUNDARAM, M.S. (2008) *Mechatronics: Integrated Mechanical Electronic Systems*. India: Wiley.

Journals

International Journal of Advanced Mechatronic Systems.

Links

This unit links to the following related units:

Unit 15: Automation, Robotics and Programmable Logic Controllers (PLCs)

Unit 54: Further Control Systems Engineering

Unit 9: Materials, Properties and Testing

Unit code **J/615/1483**

Unit level **4**

Credit value **15**

Introduction

The world we live in would be a very different place without the sophisticated engineering materials currently available. Many of the things we take for granted, such as telecommunications, air travel, safe and low-cost energy, or modern homes, rely on advanced materials development for their very existence. Successful engineering application and innovation is dependent upon the appropriate use of these materials, and the understanding of their properties.

This unit introduces students to the atomic structure of materials and the way it affects the properties, physical nature and performance characteristics of common manufacturing materials; how these properties are tested, and modified by various processing treatments; and problems that occur which can cause materials to fail in service.

On successful completion of this unit students will be able to explain the relationship between the atomic structure and the physical properties of materials, determine the suitability of engineering materials for use in a specified role, explore the testing techniques to determine the physical properties of an engineering material and identify the causes of in-service material failure.

Learning Outcomes

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

1. Explain the relationship between the atomic structure and the physical properties of materials.
2. Determine the suitability of engineering materials for use in a specified role.
3. Explore the testing techniques to determine the physical properties of an engineering material.
4. Recognise and categorise the causes of in-service material failure.

Essential Content

LO1 **Explain the relationship between the atomic structure and the physical properties of materials**

Physical properties of materials:

Classification and terminology of engineering materials

Material categories: metallic, ceramic, polymer and composites

Atomic structure, electrostatic covalent and ionic bonding

Crystalline structures: body-centred and face-centred cubic lattice and hexagonal close packed

Characteristics and function of ferrous, non-ferrous phase diagrams, amorphous and crystalline polymer structures

LO2 **Determine the suitability of engineering materials for use in a specified role**

Materials used in specific roles:

The relationship between product design and material selection

Categorising materials by their physical, mechanical, electrical and thermal properties

The effect heat treatment and mechanical processes have on material properties

How environmental factors can affect material behaviour of metallic, ceramic, polymer and composite materials

Consideration of the impact that forms of supply and cost have on material selection

LO3 **Explore the testing techniques to determine the physical properties of an engineering material**

Testing techniques:

Destructive and non-destructive tests used to identify material properties

The influence of test results on material selection for a given application

Most appropriate tests for the different categories of materials

Undertaking mechanical tests on each of the four material categories for data comparison and compare results against industry recognised data sources, explain reasons for any deviation found

LO4 **Recognise and categorise the causes of in-service material failure**

Material failure:

Reasons why engineered components fail in service

Working and environmental conditions that lead to material failure

Common mechanisms of failure for metals, polymers, ceramics and composites

Reasons for failure in service

Preventative measures that can be used to extend service life

Learning Outcomes and Assessment Criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Explain the relationship between the atomic structure and the physical properties of materials</td><td rowspan="2">D1 Explain how composition and structure of materials influence the properties of the parent material across the material’s range</td></tr>
<tr><td>P1 Describe the crystalline structure of the body-centred cubic cell, face-centred cubic cell and hexagonal close packed cell
P2 Identify the different material properties that are associated with amorphous and crystalline polymer structures</td><td>M1 Describe physical, mechanical, electrical and thermal material properties, identifying practical applications for each property if it were to be used in an engineering context</td></tr>
<tr><td colspan="2">LO2 Determine the suitability of engineering materials for use in a specified role</td><td rowspan="2">D2 Explain why the behaviour of materials is considered such an important factor when selecting a material for a given product or application</td></tr>
<tr><td>P3 Provide a list of the four materials categories, including an example of a product and application for each material identified
P4 Identify the specific characteristics related to the behaviour of the four categories of engineering materials</td><td>M2 Describe, with examples, the effect heat treatment and mechanical processes have on material properties</td></tr>
<tr><td colspan="2">LO3 Explore the testing techniques to determine the physical properties of an engineering material</td><td rowspan="2">D3 Analyse the results of mechanical tests on each of the four material categories for data comparison and compare results against industry recognised data sources, explaining any differences found</td></tr>
<tr><td>P5 Describe the six most common tests used to identify material properties
P6 Describe the non-destructive testing processes – dye penetrant, magnetic particle, ultrasonic and radiography – and include an example application for each</td><td>M3 Explain how test results influence material selection for a given application</td></tr>
</table>

Pass	Merit	Distinction
LO4 Recognise and categorise the causes of in-service material failure		**D4** Explain the methods that could be used for estimating product service life when a product is subject to creep and fatigue loading
P7 Describe six common mechanisms of failure **P8** Describe working and environmental conditions that lead to failure for a product made from material from each of the four material categories	**M4** Explain, with examples, the preventative measures that can be used to extend the service life of a given product within its working environment	

Recommended Resources

Textbooks

ASHBY, M. (2005) *Materials Selection in Mechanical Design*. 3rd Ed. Elsevier.

CALLISTER, W. and RETHWISCH, D. (2009) *Fundamentals of Materials Science and Engineering: An Integrated Approach*. 4th Ed. Wiley.

Links

This unit links to the following related units:

Unit 1: Engineering Design

Unit 10: Mechanical Workshop Practices

Unit 12: Engineering Management

Unit code	**Y/615/1486**
Unit level	**4**
Credit value	**15**

Introduction

Managing engineering projects is one of the most complex tasks in engineering. Consider the mass production of millions of cars, sending a man or women into space or extracting oil or gas from deep below the surface of the earth. Bringing the materials and skills together in a cost effective, safe and timely way is what engineering management is all about.

This unit introduces students to engineering management principles and practices, and their strategic implementation.

Topics included in this unit are: the main concepts and theories of management and leadership, fundamentals of risk management, operational management, project and operations management theories and tools, the key success measures of management strategies, and planning tools.

On successful completion of this unit students will be able to investigate key strategic issues involved in developing and implementing engineering projects and solutions, and explain professional codes of conduct and the relevant legal requirements governing engineering activities.

Learning Outcomes

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

1. Examine the application of management techniques, and cultural and leadership aspects to engineering organisations.
2. Explore the role of risk and quality management in improving performance in engineering organisations.
3. Investigate the theories and tools of project and operations management when managing activities and optimising resource allocation.
4. Perform activities that improve current management strategies within an identified element of an engineering organisation.

Essential Content

LO1 **Examine the application of management techniques, and cultural and leadership aspects to engineering organisations**

Main concepts and theories of management and leadership:

Influence on organisational culture and communication practices

Effect of change within an organisation on its culture and behaviour

Management and leadership theories:

Management and leadership theories

Managerial behaviour and effectiveness

Organisational culture and change

Organisational communication practices

LO2 **Explore the role of risk and quality management in improving performance in engineering organisations**

Fundamentals of quality management:

Introduction to monitoring and controlling

Most appropriate quality improvement methodologies and practices for different business areas, projects and processes in order to lower risk and improve processes

Risk and quality management:

Risk management processes

Risk mapping and risk matrix

Quality management theories

Continuous improvement practices

Principles, tools and techniques of Total Quality Management (TQM)

LO3 **Investigate the theories and tools of project and operations management when managing activities and optimising resource allocation**

Operation management:

Main areas and stages of projects and operations management

Most important methodologies focusing on eliminating waste and smoothing the process flows without scarifying quality

*Project and operations manag*ement theories and tools:*

Project appraisal and life cycle

Logistics and supply chain management

Operations management

Resources management

Sustainability

Legal requirements governing employment, health, safety and environment

LO4 **Perform activities that improve current management strategies within an identified element of an engineering organisation**

The key success of management strategies:

Following processes from end to end, from suppliers to customers

Identifying areas critical for the success of a project or process

Planning tools:

Gantt charts

Flow charts

Critical analysis and evaluation

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Examine the application of management techniques, and cultural and leadership aspects to engineering organisations		**D1** Propose recommendations for the most efficient application of management techniques
P1 Explain management and leadership theories and techniques used within engineering organisations	**M1** Justify different management techniques with emphasis on cultural and leadership aspects and their applications to engineering organisations	
LO2 Explore the role of risk and quality management in improving performance in engineering organisations		**D2** Provide supported and justified recommendations for the most efficient and effective risk and quality management practices
P2 Describe the role and importance of risk and quality management processes and their impact on engineering organisations	**M2** Explain how risk and quality management strategies encourage performance improvements within engineering organisations	
LO3 Investigate the theories and tools of project and operations management when managing activities and optimising resource allocation		**D3** Analyse the relative merits of theories and tools of project and operations management, with a focus on their relevance when managing activities and optimising resource allocation
P3 Identify project and operations management tools used when managing activities and resources within the engineering industry	**M3** Analyse the most effective project and operations management tools used when managing activities and optimising resource allocation	
LO4 Perform activities that improve current management strategies within an identified element of an engineering organisation		**D4** Conduct a full analysis of the management processes within an engineering organisation (or case study) and make fully justified recommendations for improvements to the management strategies
P4 Define the range of processes available to improve management processes within an engineering organisation	**M4** Explore activities that will improve management strategies within an engineering organisation	

Recommended Resources

Textbooks

BOWERSOX, D.J., CLOSS, D. and BIXBY, M. (2012) *Supply Chain Logistics Management*. 4th Ed. McGraw-Hill.

HILL, A. and HILL, T. (2009) *Manufacturing Operations Strategy: Texts and Cases*. 3rd Ed. Palgrave Macmillan.

OAKLAND, J.S. (2015) *Statistical Process Control*. 6th Ed. Routledge.

Websites

http://strategicmanagement.net/	Strategic Management Society (General Reference)
http://www.journals.elsevier.com/	Elsevier Journal of Operations Management (Journal)
http://www.emeraldgrouppublishing.com	Emerald Publishing International Journal of Operations & Production Management (e-Journal)

Links

This unit links to the following related units:

Unit 4: Managing a Professional Engineering Project

Unit 35: Professional Engineering Management

Unit 23: Computer Aided Design and Manufacture (CAD/CAM)

Unit code **J/615/1497**

Unit level **4**

Credit value **15**

Introduction

The capacity to quickly produce finished components from a software model is now essential in the competitive world of manufacturing. Businesses now invest heavily in Computer Aided Design (CAD) software, Computer Aided Manufacture (CAM) software and Computer Numerical Control (CNC) machines to facilitate this, thus reducing product lead times. CAD gives design engineers the platform to creatively model components that meet the specific needs of the consumer. When these models are combined with CAM software, manufacturing is made a reality.

This unit introduces students to all the stages of the CAD/CAM process and to the process of modelling components using CAD software specifically suitable for transferring to CAM software. Among the topics included in this unit are: programming methods, component set-up, tooling, solid modelling, geometry manipulation, component drawing, importing solid model, manufacturing simulation, data transfer, CNC machine types and inspections.

On successful completion of this unit students will be able to illustrate the key principles of manufacturing using a CAD/CAM system; produce 3D solid models of a component suitable for transfer into a CAM system; use CAM software to generate manufacturing simulations of a component; and design a dimensionally accurate component on a CNC machine using a CAD/CAM system.

Learning Outcomes

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

1. Describe the key principles of manufacturing using a CAD/CAM system.
2. Produce 3D solid models of a component suitable for transfer into a CAM system.
3. Use CAM software to generate manufacturing simulations of a component.
4. Design and produce a dimensionally accurate component on a CNC machine using a CAD/CAM system.

Essential Content

LO1 **Describe the key principles of manufacturing using a CAD/CAM system**

Hardware:

CAD workstation, printers, USB flash drives and network cables

Software:

Operating systems, hard disk requirements, processor, CAD software e.g. SolidWorks, Autodesk Inventor, CATIA; CAM software e.g. Edgecam, Delcam, GibbsCAM, SolidCAM

Inputs:

CAD model, material specifications, tooling data, spindle speeds and feed rate data calculations

Outputs:

CAM files, program code and coordinates, manufacturing sequences, tooling requirements, auxiliary data

Programming methods:

CAD/CAM, manual programming, conversational programming

Component set-up:

Zero datum setting, tool set-up and offsets, axis of movements

Work-holding:

Machine vice, chuck, fixtures, clamping, jigs

Tooling:

Milling cutters, lathe tools, drills, specialist tooling, tool holders, tool turrets and carousels

LO2 **Produce 3D solid models of a component suitable for transfer into a CAM system**

Solid modelling:

Extrude, cut, fillet, chamfer, holes, sweep, revolve, lines, arcs, insert planes, properties of solid models e.g. mass, centre of gravity, surface area

Geometry manipulation:

Mirror, rotate, copy, array, offset

Component drawing:

Set-up template, orthographic and multi-view drawings, sections, scale, dimensions, drawing

Attributes e.g. material, reference points, tolerances, finish

LO3 **Use CAM software to generate manufacturing simulations of a component**

Import solid model:

Set-up, model feature and geometry identification, stock size, material

Manufacturing simulation:

Operations e.g. roughing and finishing, pockets, slots, profiling, holes, tool and work change positions, tool sizes and IDs, speeds and feeds, cutter path simulations, program editing

LO4 **Design and produce a dimensionally accurate component on a CNC machine using a CAD/CAM system**

CNC machine types:

Machining centres, turning centres, MCUs e.g. Fanuc, Siemens, and Heidenhain

Data transfer:

Structured data between CAD and CAM software e.g. datum position and model orientation; file types e.g. SLDPRT, parasolid, STL, IGES, DXF; transfer to CNC machine e.g. network, USB, Ethernet

Inspection:

Manual inspection e.g. using Vernier gauges, bore micrometres

Automated inspection e.g. co-ordinate measuring machine (CMM), stages of inspection throughout manufacturing process

Learning Outcomes and Assessment Criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Describe the key principles of manufacturing using a CAD/CAM system</td><td rowspan="2">D1 Critically evaluate, using illustrative examples, the impact of different machining conditions and specifications on component manufacturing</td></tr>
<tr><td>P1 Describe the hardware and software elements of a typical CAD/CAM system
P2 Describe, with examples, the inputs and outputs of the CAD/CAM process
P3 Explain the different methods of component set-up, work-holding and tooling available on CNC machines</td><td>M1 Analyse the suitability of different programming methods of CNC machines</td></tr>
<tr><td colspan="2">LO2 Produce 3D solid models of a component suitable for transfer into a CAM system</td><td rowspan="2">D2 Critically evaluate the effectiveness of using a CAD/CAM system and solid modelling to manufacture components</td></tr>
<tr><td>P4 Design and produce a CAD solid model of a component to be manufactured on a CNC machine
P5 Design a working drawing of a component containing specific manufacturing detail</td><td>M2 Assess the importance of using different geometry manipulation methods for efficient model production</td></tr>
<tr><td colspan="2">LO3 Use CAM software to generate manufacturing simulations of a component</td><td rowspan="2">D3 Analyse the effect of applying different manufacturing techniques and modifications to achieve an optimised production time</td></tr>
<tr><td>P6 Use CAM software to generate a geometrically accurate CAD solid model of a component</td><td>M3 Using CAM software, generate cutter tool path simulations</td></tr>
</table>

Pass	Merit	Distinction
LO4 Design and produce a dimensionally accurate component on a CNC machine using a CAD/CAM system		**D4** Critically analyse, giving illustrative examples, the different methods of data transfer through a CAD/CAM system
P7 Detail a part program for a component using CAM software and transfer the part program to a CNC machine and manufacture a component **P8** Describe the structural elements of a CNC Machining Centre **P9** Review a component manufactured on a CNC machine to verify its accuracy	**M4** Analyse different methods of component inspection used in manufacturing	

Recommended Resources

Textbooks

KUNWOO, L. (2000) *Principles of CAD/CAM/CAE*. Pearson.

McMAHAN, C. and BROWNE, J. (1999) *CADCAM: Principles, Practice and Manufacturing Management*. Prentice Hall.

Links

This unit links to the following related units:

Unit 1: Engineering Design