# BTEC HIGHER NATIONALS

# **HNC Engineering**

# UNIT DIRECTORY 2021/22

First Teaching from September 2018 First Certification from 2019

> Higher National Certificate Lvl 4



# HNC Engineering Programme Structure

### 120 Credits

Unit Number	Unit Title	Credits	Level	Core/ Optional
1	Engineering Design	15	4	Core
2	Engineering Maths	15	4	Core
3	Engineering Science	15	4	Core
4	Managing a Professional Engineering Project (Pearson Set)	15	4	Core
6	Mechatronics	15	4	Optional
12	Engineering Management	15	4	Optional
19	Electrical and Electronic Principles	15	5	Optional
23	Computer Aided Design and Manufacture	15	5	Optional

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	
<b>LO1</b> Plan a design solutio design specification in results brief and requirements	<b>D1</b> Compare and contrast the completed design specification		
<b>P1</b> Produce a design specification from a given design brief	<b>M1</b> Evaluate potential planning techniques, presenting a case for the	against the relevant industry standard specification	
<b>P2</b> Explain the influence of the stakeholder's design brief and requirements in the preparation of the design specification	method chosen <b>M2</b> Demonstrate critical path analysis techniques in design project scheduling/planning and explain its use		
<b>P3</b> Produce a design project schedule with a graphical illustration of the planned activities			
<b>LO2</b> Formulate possible to the student-prepared des	<b>D2</b> Evaluate potential technical solutions,		
<b>P4</b> Explore industry standard evaluation and analytical tools in formulating possible technical solutions	<b>M3</b> Apply the principles of modelling, simulation and/or prototyping, using appropriate software, to develop an appropriate design solution	presenting a case for the final choice of solution	
<b>P5</b> Use appropriate design techniques to produce a possible design solution			

Pass	Merit	Distinction	
<b>LO3</b> Prepare an industry- design report	<b>D3</b> Evaluate the effectiveness of the		
<ul> <li>P6 Prepare an industry- standard engineering technical design report</li> <li>P7 Explain the role of design specifications and standards in the technical design report</li> </ul>	<b>M4</b> Assess any compliance, safety and risk management issues specific to the technical design report	industry standard engineering technical design report for producing a fully compliant finished product	
<b>LO4</b> Present to an audien the design report and eva	<b>D4</b> Justify potential improvements to the		
<b>P8</b> Present the recommended design solution to the identified audience	<b>M5</b> Reflect on the effectiveness of the chosen communication strategy in presenting the design solution	design solution and/or presentation based on reflection and/or feedback	
<b>P9</b> Explain possible communication strategies and presentation methods that could be used to inform the stakeholders of the recommended 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 MathsUnit codeM/615/1476Unit typeCoreUnit level4Credit value15

# Introduction

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

The aim of this unit is to develop students' skills in the mathematical principles and theories that underpin the engineering curriculum. Students will be introduced to mathematical methods and statistical techniques in order to analyse and solve problems within an engineering context.

On successful completion of this unit students will be able to employ mathematical methods within a variety of contextualised examples, interpret data using statistical techniques, and use analytical and computational methods to evaluate and solve engineering problems.

# Learning Outcomes

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

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

# **Essential Content**

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

Mathematical concepts:

Dimensional analysis

Arithmetic and geometric progressions

Functions:

Exponential, logarithmic, trigonometric and hyperbolic functions

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

Summary of data: Mean and standard deviation of grouped data Pearson's correlation coefficient Linear regression Charts, graphs and tables to present data

Probability theory:

Binomial and normal distribution

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

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

Vector functions:

Vector notation and properties

Representing quantities in vector form

Vectors in three dimensions

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

# Differential calculus:

Definitions and concepts

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

Differentiation of functions

Differentiation of functions including:

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

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

# Integral calculus:

Definite and indefinite integration

Integrating to determine area

Integration of functions including:

- common/standard functions
- using substitution
- by parts

Exponential growth and decay

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

# Engineering problems involving calculus:

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

# Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
<b>LO1</b> Identify the relevance of ma variety of conceptualised engine	LO1 & LO2 D1 Present data in a	
<b>P1</b> Apply dimensional analysis techniques to solve complex problems	<b>M1</b> Use dimensional analysis to derive equations	method that can be understood by a non- technical audience
<b>P2</b> Generate answers from contextualised arithmetic and geometric progressions		
<b>P3</b> Determine solutions of equations using exponential, logarithmic, trigonometric and hyperbolic functions		
<b>LO2</b> Investigate applications of s interpret, organise and present o		
<b>P4</b> Summarise data by calculating mean and standard deviation	<b>M2</b> Interpret the results of a statistical hypothesis test conducted from a	
<b>P5</b> Calculate probabilities within both binomially distributed and normally distributed random variables	given scenario	

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

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

# **Essential Content**

# LO1 Examine scientific data using both quantitative and qualitative methods

# International system of units:

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

- SI derived units with special names and symbols
- SI prefixes and their representation with engineering notation

# Interpreting data:

Investigation using the scientific method to gather appropriate data

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

Summarising quantitative and qualitative data with appropriate graphical representations

Using presentation software to present data to an audience

# LO2 **Determine parameters within mechanical engineering systems**

# Static and dynamic forces:

Representing loaded components with space and free body diagrams

Calculating support reactions of beams subjected to concentrated and distributed loads

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

Fluid mechanics and thermodynamics:

Archimedes' principle and hydrostatics

Continuity of volume and mass flow for an incompressible fluid

Effects of sensible/latent heat of fluid

Heat transfer due to temperature change and the thermodynamic process equations

# LO3 Explore the characteristics and properties of engineering materials

# Material properties:

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

Mechanical and electromagnetic properties of materials

Material failure:

Destructive and non-destructive testing of materials

The effects of gradual and impact loading on a material.

Degradation of materials and hysteresis

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

# D.C. circuit theory:

Voltage, current and resistance in D.C. networks

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

# A.C. circuit theory:

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

**RLC** circuits

# Magnetism:

Characteristics of magnetic fields and electromagnetic force

The principles and applications of electromagnetic induction

# Learning Outcomes and Assessment Criteria

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

Pass	Merit	Distinction
<b>LO3</b> Explore the characteris engineering materials	<b>D3</b> Compare and contrast theoretical	
<b>P6</b> Describe the structural properties of metals and non-metals with reference to their material properties	<b>M3</b> Review elastic and electromagnetic hysteresis in different materials	material properties of metals and non-metals with practical test data
<b>P7</b> Explain the types of degradation found in metals and non-metals		
<b>LO4</b> Analyse applications of A.C./D.C. circuit theorems, electromagnetic principles and properties		<b>D4</b> Evaluate different techniques used to solve
<b>P8</b> Calculate currents and voltages in D.C. circuits using circuit theorems	<b>M4</b> Explain the principles and applications of electromagnetic	problems on a combined series-parallel RLC circuit using A.C. theory.
<b>P9</b> Describe how complex waveforms are produced from combining two or more sinusoidal waveforms.	induction	
<b>P10</b> Solve problems on series RLC circuits with A.C. theory.		

# **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<br/>Engineering ProjectUnit codeA/615/1478Unit typeCoreUnit level4Credit value15

# 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 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.

# **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 ongoing 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

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

# **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

Pass	Merit	Distinction
<b>LO1</b> Examine the design and operational characteristics of a mechatronic system		<b>D1</b> Investigate an actual mechatronics system
<b>P1</b> Describe the key components of a given mechatronics system <b>P2</b> Identify the types of	<b>M1</b> Explore how the mechatronics components operate as part of an integrated system	specification to propose alternative solutions
actuators, sensors and transducers used in the mechatronics system	<b>M2</b> Investigate the methods of control used by mechatronics systems	
<b>LO2</b> Design a mechatronic system specification for a given application		<b>D2</b> Evaluate the operational capabilities
<b>P3</b> Select the relevant sensor and the appropriate actuator technologies and produce a design specification suitable for these selections	<b>M3</b> Justify the sensor and actuator technologies selected with reference to available alternatives	and limitations of the mechatronics system design specification produced
<b>LO3</b> Examine the operation and function of a mechatronics system using simulation and modelling software		<b>D3</b> Explain the function and operation of a simulated mechatronics
<b>P4</b> Demonstrate industry standard mechatronics simulation/modelling software	<b>M4</b> Describe the advantages and disadvantages of the software simulation	system

Pass	Merit	Distinction
LO4 Identify and correct faults in a mechatronic system		<b>D4</b> Investigate the
<ul> <li>P5 Explain the safe use of fault finding test equipment</li> <li>P6 Locate and rectify faults on a mechatronic system</li> </ul>	<b>M5</b> Apply and document the correct use of fault finding techniques/ methods	causes of faults on a mechatronics system and suggest alternatives to the design specification to improve reliability

# **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 12:	<b>Engineering Management</b>
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 management 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
<b>LO1</b> Examine the application of management techniques, and cultural and leadership aspects to engineering organisations		<b>D1</b> Propose recommendations for the most efficient application
<b>P1</b> 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	of management techniques
<b>LO2</b> Explore the role of risk and quality management in improving performance in engineering organisations		<b>D2</b> Provide supported and justified
<b>P2</b> 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	recommendations for the most efficient and effective risk and quality management practices
<b>LO3</b> Investigate the theories and tools of project and operations management when managing activities and optimising resource allocation		<b>D3</b> Analyse the relative merits of theories and tools of project and
<b>P3</b> Identify project and operations management tools used when managing activities and resources within the engineering industry	<b>M3</b> Analyse the most effective project and operations management tools used when managing activities and optimising resource allocation	operations management, with a focus on their relevance when managing activities and optimising resource allocation

Pass	Merit	Distinction
<b>LO4</b> Perform activities that improve current management strategies within an identified element of an engineering organisation		<b>D4</b> Conduct a full analysis of the management processes within an
<b>P4</b> Define the range of processes available to improve management processes within an engineering organisation	<b>M4</b> Explore activities that will improve management strategies within an engineering organisation	engineering organisation (or case study) and make fully justified recommendations for improvements to the management strategies

# **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 19:	Electrical and Electronic Principles
Unit code	M/615/1493
Unit level	4
Credit value	15

# Introduction

Electrical engineering is mainly concerned with the movement of energy and power in electrical form, and its generation and consumption. Electronics is mainly concerned with the manipulation of information, which may be acquired, stored, processed or transmitted in electrical form. Both depend on the same set of physical principles, though their applications differ widely. A study of electrical or electronic engineering depends very much on these underlying principles; these form the foundation for any qualification in the field, and are the basis of this unit.

The physical principles themselves build initially from our understanding of the atom, the concept of electrical charge, electric fields, and the behaviour of the electron in different types of material. This understanding is readily applied to electric circuits of different types, and the basic circuit laws and electrical components emerge. Another set of principles is built around semiconductor devices, which become the basis of modern electronics. An introduction to semiconductor theory leads to a survey of the key electronic components, primarily different types of diodes and transistors.

Electronics is very broadly divided into analogue and digital applications. The final section of the unit introduces the fundamentals of these, using simple applications. Thus, under analogue electronics, the amplifier and its characteristics are introduced. Under digital electronics, voltages are applied as logic values, and simple circuits made from logic gates are considered.

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

# Learning Outcomes

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

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

# **Essential Content**

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

# *Fundamental electrical quantities and concepts:*

Charge, current, electric field, energy in an electrical context, potential, potential difference, resistance, electromotive force, conductors and insulators

### Circuit laws:

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

### Energy and power:

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

# LO2 Analyse circuits with sinusoidal voltages and currents

# Fundamental quantities of periodic waveforms:

Frequency, period, peak value, phase angle, waveforms, the importance of sinusoids

# Mathematical techniques:

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

### *Reactive components:*

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

### Circuits with sinusoidal sources:

Current and voltage in series and parallel RL, RC and RLC circuits. Frequency response and resonance

Mains voltage single-phase systems. Power, root-mean-square power quantities, power factor

# Ideal transformer and rectification:

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

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

### Semiconductor material:

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

### *Simple semiconductor devices:*

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

### Simple semiconductor applications:

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

Transistors: switches and signal amplifiers

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

### Analogue concepts:

Analogue quantities, examples of electrical representation of, for example, audio, temperature, speed, or acceleration

The voltage amplifier; gain, frequency response, input and output resistance, effect of source and load resistance (with source and amplifier output modelled as Thevenin equivalent)

### Digital concepts:

Logic circuits implemented with switches or relays

Use of voltages to represent logic 0 and 1, binary counting

Logic Gates (AND, OR, NAND, NOR) to create simple combinational logic functions

Truth Tables

# Learning Outcomes and Assessment Criteria

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

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

# **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.

# Links

This unit links to the following related units: *Unit 20: Digital Principles Unit 22: Electronic Circuits and Devices Unit 52: Further Electrical, Electronic and Digital Principles* 

# Unit 23:Computer Aided Design and<br/>Manufacture (CAD/CAM)Unit codeJ/615/1497Unit level4Credit value15

# 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

Pass	Merit	Distinction
<b>LO1</b> Describe the key principles of manufacturing using a CAD/CAM system		<b>D1</b> Critically evaluate, using illustrative
<b>P1</b> Describe the hardware and software elements of a typical CAD/CAM system	<b>M1</b> Analyse the suitability of different programming methods of CNC machines	examples, the impact of different machining conditions and
<b>P2</b> Describe, with examples, the inputs and outputs of the CAD/CAM process		component manufacturing
<b>P3</b> Explain the different methods of component set-up, work-holding and tooling available on CNC machines		
<b>LO2</b> Produce 3D solid models of a component suitable for transfer into a CAM system		<b>D2</b> Critically evaluate the effectiveness of
<b>P4</b> Design and produce a CAD solid model of a component to be manufactured on a CNC machine	<b>M2</b> Assess the importance of using different geometry manipulation methods for efficient model production	using a CAD/CAM system and solid modelling to manufacture components
<b>P5</b> Design a working drawing of a component containing specific manufacturing detail		

Pass	Merit	Distinction
<b>LO3</b> Use CAM software to generate manufacturing simulations of a component		<b>D3</b> Analyse the effect of applying different
<b>P6</b> Use CAM software to generate a geometrically accurate CAD solid model of a component	<b>M3</b> Using CAM software, generate cutter tool path simulations	manufacturing techniques and modifications to achieve an optimised production time
<b>LO4</b> Design and produce a dimensionally accurate component on a CNC machine using a CAD/CAM system		<b>D4</b> Critically analyse, giving illustrative
<b>P7</b> Detail a part program for a component using CAM software and transfer the part program to a CNC machine and manufacture a component	<b>M4</b> Analyse different methods of component inspection used in manufacturing	examples, the different methods of data transfer through a CAD/CAM system
<b>P8</b> Describe the structural elements of a CNC Machining Centre		
<b>P9</b> Review a component manufactured on a CNC machine to verify its accuracy		

# **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