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Pearson Edexcel Level 3 Advanced Subsidiary GCE in Engineering (Single Award) (8731)

Pearson Edexcel Level 3 Advanced GCE in Engineering (Single Award) (9731)

Specification

Applied GCE

First Examination 2014

Issue 5

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This specification is Issue 5. Key changes are sidelined. We will inform centres of any changes to this issue. The latest issue can be found on the Edexcel website: www.edexcel.com

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Contents

Introduction

This suite of nine qualifications comprises General Certificates of Education in:

- Applied Art and Design
- Applied Business
- Applied ICT
- Engineering
- Health and Social Care
- Leisure Studies
- Media
- Performing Arts
- Travel and Tourism.

These qualifications are designed to give learners a broad introduction to a vocational sector.

Edexcel GCE in Engineering

These qualifications have been developed to provide a broad educational basis for further training, further education or for moving into appropriate employment within the engineering sector. They have been designed to be delivered in a work-related context and to allow learners to develop an understanding of the engineering sector.

Qualification codes

Each qualification title is allocated a National Qualifications Framework (NQF) code.

The National Qualifications Framework (NQF) code is known as a Qualification Number (QN). This is the code that features in the DfE Section 96, and on the LARA as being eligible for 16-18 and 19+ funding, and is to be used for all qualification funding purposes. The QN is the number that will appear on the student's final certification documentation.

The QNs for the qualifications in this publication are:

- Pearson Edexcel Level 3 Advanced Subsidiary GCE in Engineering (Single Award): 100/4253/2
- Pearson Edexcel Level 3 Advanced GCE in Engineering (Single Award): 100/4254/4.

Qualification overview

Structure

Advanced Subsidiary/Advanced GCE (Single Award)

All Single Award Advanced GCE qualifications in this suite comprise six equally-weighted units and contain an Advanced Subsidiary subset of three AS units. The AS is the first half of a GCE course and contributes 50 per cent of the total Advanced GCE marks. The A2, the second half of the Advanced GCE, comprises the other 50 per cent of the total Advanced GCE marks.

Advanced Subsidiary/Advanced GCE (Double Award)*

All Advanced GCE (double award) qualifications in this suite comprise 12 equally-weighted units and contain an Advanced Subsidiary (Double Award) subset of six AS units. The Advanced Subsidiary (Double Award) is the first half of an Advanced GCE (Double Award) course and contributes 50 per cent of the total Advanced GCE (Double Award) marks. The A2, the second half of the Advanced GCE (Double Award), comprises the other 50 per cent of the total Advanced GCE (Double Award) marks.

Advanced GCE with Advanced Subsidiary (Additional)

All Advanced GCE with Advanced Subsidiary (Additional) qualifications in this suite comprise nine equally-weighted units.

Guided learning hours

The number of guided learning hours for the three-unit Advanced Subsidiary GCE (Single Award) qualification is 180.

The number of guided learning hours for the six-unit Advanced GCE (Single Award) qualification is 360.

***The Pearson Edexcel Level 3 GCE in Engineering is not available as an Advanced Subsidiary (Double Award), an Advanced GCE (Double Award), or as an Advanced GCE with Advanced Subsidiary (Additional) qualification.**

Overview of units

Unit	Title	Unit code	Level	AS	GCE	Assessment mode	Assessment availability
1	Engineering Materials, Processes and Techniques	6931	AS	Compulsory	Compulsory	External	June
2	The Role of the Engineer	6932	AS	Compulsory	Compulsory	Internal	June
3	Principles of Design, Planning and Prototyping	6933	AS	Compulsory	Compulsory	Internal	June
4	Applied Engineering Systems	6934	A2	N/A	Compulsory	External	June
5	The Engineering Environment	6935	A2	N/A	Compulsory	Internal	June
6	Applied Design, Planning and Prototyping	6936	A2	N/A	Compulsory	Internal	June

Rationale

This suite of nine General Certificates of Education is part of the Level 3 provision of the National Qualifications Framework (NQF).

These GCEs aim to:

- widen participation in vocationally-related learning
- allow learners to experience vocationally-related learning to see if it is suitable for them
- enable learners to make valid personal choices on completion of the qualification
- raise attainment at Level 3/Advanced level of the NQF.

The broad objectives of the GCEs are to:

- introduce learners to work-related learning
- give learners a broad introduction to a vocational sector
- give learners the technical knowledge, skills and understanding associated with the subject at this level
- equip learners with some of skills they will need in the workplace or in further education or training
- empower learners to take charge of their own learning and development
- provide a range of teaching, learning and assessment styles to motivate learners to achieve their full potential.

The Applied GCE suite of qualifications contributes to the quality and coherence of national provision, as shown by their place in the Government's Green Paper '14–19 Extending Opportunities, Raising Standards'.

The GCE in Engineering has been designed to provide a broad educational basis for further education or for moving into employment within the engineering sector. This is achieved by ensuring that learners develop the general skills, knowledge and understanding needed within the sector. This qualification conforms to the General Qualification Criteria for GCEs and to the subject criteria for GCE qualifications in Engineering, which set out the knowledge, understanding, skills and schemes of assessment common to all GCE qualifications in the subject. Subject criteria help ensure consistent and comparable standards in the same subject area across awarding bodies and help further and higher education institutions and employers know what has been studied and assessed.

In particular, the aims of the GCE qualifications in Engineering are to:

- understand the nature of different areas of engineering and the demands of the engineering and related industries and evaluate the social, economic and environmental impact these have on society, identifying ethical issues that may arise
- develop a knowledge and understanding of the range of engineering technologies, and the complex sub-groups that make up engineering and related industries
- apply their knowledge of engineering technology in a variety of engineering contexts, including design, to become safe users of equipment, techniques and procedures used in engineering contexts, including those dependent on ICT
- apply their knowledge and understanding of engineering, its practical and technological aspects, through project-based practical study of engineering design, production, commissioning and maintenance.

Recommended prior learning

Learners who would benefit most from a GCE in Engineering are likely to have:

EITHER **five** GCSEs grades A*–C, including one or more of the following:

- a Level 2 qualification such as GCSE (Double Award) in Engineering, GCSE (Double Award) in Manufacturing
- a Level 2 qualification in GCSE Mathematics
- a Level 2 qualification in GCSE Science.

OR **one** of the following:

- Edexcel Level 2 BTEC First Diploma in Electronics
- Edexcel Level 2 BTEC First Diploma in Manufacturing Engineering
- Edexcel Level 2 BTEC First Diploma in Operations and Maintenance Engineering.

Progression

This qualification provides progression to further education, training or employment. Appropriate further education includes Edexcel Level 4 BTEC Higher Nationals in Engineering, NVQ Engineering Levels 3/4, appropriate foundation degrees or degrees in engineering-related subjects.

Classification code

Every qualification is assigned a national classification code indicating the subject area to which it belongs. The classification code for this qualification is 0009.

Centres should be aware that learners who enter for more than one Level 3 qualification with the same classification code will have only one grade (the highest) counted for the purpose of the school and college performance tables.

Links with other qualifications

Edexcel GCSE (Double Award) in Engineering

The GCE in Engineering builds on the underpinning knowledge gained through the study of the GCSE (Double Award) in Engineering as follows:

- GCE in Engineering *Unit 2: The Role of the Engineer* builds on the GCSE (Double Award) Unit 3: Application of technology
- GCE in Engineering *Unit 3: Principles of Design, Planning and Prototyping* builds on the GCSE (Double Award) Unit 1: Design and Graphical Communication and Unit 2: Engineered Products.

Edexcel GCE in Design and Technology

The GCE Engineering has a general overlap with the study of the GCE in Design and Technology as follows:

- GCE in Engineering *Unit 3: Principles of design, planning and prototyping* and *Unit 6: Applied design, planning and prototyping* has an overlap with Edexcel GCE in Design and Technology: Product Design Unit 1: Portfolio of Creative Skills and Unit 4: Commercial Design
- GCE in Engineering *Unit 1: Engineering Materials, Processes and Techniques* has specific links to Edexcel GCE in Design and Technology: Product Design Unit 2: Design and Technology in Practice.

Edexcel Level 3 BTEC National in Engineering

There are links to the content of the following Edexcel Level 3 BTEC National in Engineering units where the GCE in Engineering could provide an introduction.

- Business Systems for Technicians
- Communications for Technicians
- Project (Electrical/Electronic/Mechanical/Manufacturing)
- Production Planning and Scheduling
- Primary Forming Processes
- Secondary Processes
- Engineering Materials
- Engineering Drawing
- Engineering Design
- Computer Aided Design
- Engineering Workplace Practices
- Health, Safety and Welfare
- Microelectronics
- Electrical and Electronic Principles.

Specification content

The guidance for learners sections are *Introduction*, *Recommended prior learning* and *What you need to learn* and, for internally assessed units only, *Assessment evidence*. The other sections give guidance for teachers.

Index of units

Unit 1: Engineering Materials, Processes and Techniques

Externally assessed

Introduction

Engineers need to be familiar with a wide range of materials, manufacturing processes and techniques in order to fully develop new products or modify existing ones.

It is important for engineers to appreciate the properties of materials as they govern the way in which they are used. Throughout this unit you will examine the properties of a range of common engineering materials and their suitability for various applications.

You will look at the way materials can be shaped into components for use in products, such as by machining or by moulding. You will also learn how different materials can be joined together to manufacture high quality finished products.

Recommended prior learning

There is no specific prior learning recommended for this unit.

External assessment

This unit will be assessed through an examination set and marked by Edexcel.

There will be a 1 hour and 30 minute examination paper.

The number of raw marks available is 90.

The examination will be available in the June examination series.

The paper will be a question and answer booklet.

Each examination paper will have one or more themes. A theme will be a common engineered product. The product(s) will provide opportunities for you to answer questions about the choice and application of particular materials, joining techniques and processing methods in the context of a specific application. You will not require actual knowledge of the product(s) to answer the questions in the examination. The product(s) will merely give a context in which you can demonstrate your subject knowledge and understanding.

What you need to learn

1.1 Materials

This section defines the range of materials with which you should become familiar.

You will become familiar with their properties, processing and joining (as defined in the following sections). You will learn about the following materials and, where appropriate, the class of material to which they belong.

Metals

Ferrous and non-ferrous

- cast iron
- copper
- aluminium
- zinc
- tin
- tungsten.

Alloys

- low carbon steel — 0.15%-0.30% carbon
- medium carbon steel — 0.30%-0.7% carbon
- high carbon steel — 0.7%-1.4% carbon
- stainless steel
- high speed steel
- duralumin
- brass.

Polymers

You will need to have an understanding of the simple molecular structure of thermoplastics and thermosetting plastics and be able to draw simple diagrams to show the significant differences between these molecular structures.

Thermoplastic polymers:

- polycarbonates
- acrylic (PMMA)
- polyethene (low and high density)
- polystyrene (PS)
- polyvinyl chloride (PVC)
- acrylonitrile-butadiene-styrene (ABS)
- polyamide (nylon)
- polytetrafluoroethylene (PTFE).

Thermosetting polymers:

- polyester resin
- urea formaldehyde (UF).

Elastomers

- rubber
- neoprene.

Adhesives

- epoxy resins (araldite)
- cyanocryalates (superglue).

Composites

- glass reinforced plastics (GRP)
- carbon fibre reinforced plastics.

Ceramics and glass

- porcelain
- borosilicate glass (Pyrex).

New materials

- shape memory alloys (SMA)
- piezoelectric actuators
- optical fibres
- heat shrink material.

1.2 Properties of materials

You should understand, and be able to describe, the important properties of the range of materials listed in section 1.1 on page 10.

You should be able to recognise, and describe, how the measurements of a property can be made. You will also need to know the units of these measurements.

Properties include:

Mechanical

- hardness
- toughness
- elasticity
- plasticity
- ductility
- malleability
- compressive strength
- tensile strength.

You should be familiar with typical stress-strain and load-extension graphs for low carbon steel. You should understand how to calculate stress, strain and Young's modulus of elasticity in a material.

Physical

- density.

Thermal

- melting point
- thermal conductivity.

Electrical

- conductivity (resistivity)
- resistance
- insulation.

Magnetic

- distinguish between magnetic and non-magnetic materials
- understand the use of hard and soft magnetic materials.

Modification of properties — the effects of heat treatment on steels

- hardening
- tempering
- annealing
- normalising
- case hardening.

Deterioration of materials

- understand why some metals deteriorate due to oxidisation (corrosion) and fatigue
- describe the degrading effect of ultra violet light on some polymers.

Relative costs of materials

You should be able to use a computerised database or tables of property values to identify materials suitable for specified applications. You should be able to explain or justify these choices in terms of the information in the databases.

1.3 Joining materials together

You will need to investigate the different techniques by which materials can be joined together, and the advantages and disadvantages of different methods of joining materials in particular situations.

Thermal joining of metals and polymers

Metals:

- soft soldering
- hard soldering
- fusion welding
  - oxyacetylene
  - manual metal arc
  - TIG
  - MIG
  - spot welding

- solid phase welding
  - friction
  - ultrasonic.

Thermoplastics:

- hot air gun and filler rods.

Mechanical joining

- screws
- nuts and bolts
- rivets
- crimping.

Adhesive bonding

- contact adhesives
- cyanoacrylates
- epoxy resin.

Knowledge of the health risks, for example fumes; and of the safety precautions for these techniques, for example fume extraction, are also required.

1.4 Materials processing

Forming

- press work
- drop forging.

Casting and moulding techniques

Metals:

- sand casting
- gravity die casting
- pressure die-casting.

Plastics:

- injection moulding
- extrusion
- blow moulding
- vacuum forming
- compression moulding
- GRP moulding.

Material removal

- sawing
- filing
- turning
- milling
- drilling
- punching
- chemical etching.

Surface treatment and finishing

- galvanising
- anodising
- polishing
- painting
- electroplating
- plastic coating
- self-finishing.

You should be able to identify and describe health and safety issues associated with the processes you have studied.

Delivering this unit

General

The context in which this unit is delivered is important, and should reflect a wide range of engineering activities and specialisms.

In order to ensure relevance, it is recommended that this unit is delivered alongside *Unit 3: Principles of Design, Planning and Prototyping*, where a broad range of opportunities to teach the practical application of knowledge and understanding of engineering materials, processes and techniques are likely to present themselves as part of a cohesive body of practical work.

Wherever possible, a practical approach to the teaching of this unit is recommended and any outside agencies that can be used to assist in making the activities as diverse as possible should be used to the benefit of learners.

Material samples

It is important that learners have experience of a range of materials and that they are familiar with their properties and processing methods. Analysis of a range of successfully engineered products would be of benefit to learners in their understanding of materials selection and processing.

Materials

Learners should understand why materials are selected for particular applications and should be able to explain why in terms of their understanding of the engineering potential of a particular material.

Alloys

Learners should understand how, in steels, the carbon content affects performance. Learners should be able to describe uses for different steels and give reasons for their choice.

Learners should understand the constituents of stainless steel and high-speed steel and describe the specialist uses of these materials.

Polymers

Learners should be able to describe the molecular structure of thermo and thermosetting plastics through a simple explanation of addition polymerisation. Learners should also know the function of Van der Waals bonding in thermoplastics and covalent bonding to produce cross-linking in thermoses.

Learners should be able to select plastic materials for particular purposes and explain and justify their choice based on a knowledge and understanding of the working properties of the selected material.

Elastomers

Rubber

Learners should understand the limitations of rubber as an engineering material and how its performance is improved through vulcanisation. They should be able to explain vulcanisation.

Neoprene

Learners should understand and explain the uses in engineering of this synthetic rubber, describing its applications and advantages over natural rubber.

Adhesives

Learners should understand the engineering application of particular adhesives and justify their selection.

Composites

Learners should understand and describe how mixing one or more materials together to form a composite can produce dramatic changes in the properties of the constituent parts of the composite.

Ceramics and glass

Learners should understand the special uses in engineering of these materials and give justifiable examples of applications.

New materials

Learners should understand the properties and uses of these materials and should be able to describe how they are useful in engineering.

Properties of materials

It is important that learners have a thorough understanding of the properties of materials and they will need to recognise how the properties of a material make it suitable for a particular application.

Learners should be encouraged to identify and classify the materials they encounter and, for the most common ones, to handle and identify them by simple means (weight, colour, magnetic or non-magnetic, hardness etc).

Mechanical properties

Learners should understand where particular mechanical properties of materials are essential to their intended use and should be able to recognise and describe the terms used in relation to them. Learners should be able to draw load/extension graphs for low carbon steel and label the elastic limit, plastic deformation area and ultimate tensile strength of the material.

Learners should be able to draw stress/strain graphs for the same material and should be able to apply calculations for:

Stress = load (N)/cross-sectional area (m2)

Strain = change in length/original length

Young's modulus of elasticity = stress/strain

Other properties

- Physical
- Thermal
- Electrical
- Magnetic.

Learners should understand and describe how these properties must be considered in order to determine the most appropriate material for a particular engineering application and how a compromise based on the intended use of a material is often used as a 'best fit' material.

Modification of properties

Heat treatment of steels

Learners should understand and describe how steels containing sufficient carbon can be hardened through heat treatment. They should explain the process of toughening hardened steel through tempering, for particular purposes. Learners should describe normalising and annealing to explain the difference between refining the crystal structure of steel and causing the structure to soften beyond its normal state.

Case hardening of low carbon and mild steels should be understood and explained by learners.

Deterioration of materials

Corrosion

Learners should understand and explain how corrosion in metals occurs, including knowledge of electrolytic or galvanic corrosion and sacrificial anodes.

Joining materials together

Thermal joining

Learners should have a working knowledge of the thermal joining processes listed in section 1.3 on page 12. They should be able to select an appropriate process and explain and justify their choice when describing the manufacture of a particular product.

Mechanical joining

Learners should be familiar with the use of the listed permanent and temporary methods of joining materials together. Learners should know that screws and bolts have a range of head shapes and thread forms.

Materials processing

Forming

Learners should be able to identify products that have been formed by processes and describe the processes. They should understand that some forming is done as a cold process and some as a hot process.

Casting and moulding techniques

Metals

Learners should understand and explain the advantages and disadvantages of each metal-casting process in terms of speed of production, surface finish, complexity of achievable shape and cost.

Plastics

Learners should be able to explain the plastic moulding/forming processes listed and give examples of products manufactured using the processes.

Learners should be aware of which processes are used with thermoplastics and which are peculiar to thermosetting plastics.

Materials removal

Learners should be able to describe the processes listed under this heading and explain in detail how and why they are used. It would be of benefit if learners could experience as many of these processes as possible, either through their own work, or through seeing the work of others.

Surface treatment and finishing

Learners should understand and explain how each of the processes in this section offers protection to the surface of metals. Learners should describe how each treatment/finish is applied and they should be aware of the potential health and safety hazards present in each process.

Industrial visits

Where it is practicable a visit to a local manufacturing company would be beneficial. This would give learners the opportunity to see some processes being used in a commercial setting, manufacturing products for the real world.

Atomic and molecular structures

It may be appropriate to relate the materials and their properties to simple atomic and molecular structures, as extension activities for some learners, to gain a greater knowledge and understanding of the topic. However, this unit should be treated as a general introduction only to material science.

Links

Other units

This unit provides underpinning knowledge which informs the design work carried out as part of *Unit 3: Principles of Design, Planning and Prototyping*. The design of products and systems requires a thorough understanding of the basic materials, their properties and processing. With this knowledge, engineers are able to design products which can be manufactured, and which will function as intended when made.

This unit also provides the basis of knowledge and understanding built on in the A2 units. An understanding of materials benefits the understanding of engineering systems.

Industry

Industrial practice is central to the delivery of this unit. The way in which materials are used in real products, and the manufacturing processes which are used in making these products, are valuable contributions to the learner's understanding of materials and their processing. The use of industrial contacts in providing visiting lectures, products of local engineering companies for learners to examine, and visits to see products being made are all valuable parts of the delivery of this unit.

Photographs and video clips would also be useful aids to explain processes and machinery used to shape and form materials. However, it is recognised that it would be impossible for learners to actually use the whole range of materials and processes covered by this unit.

Resources

Please note that while resources are checked at the time of publication, materials may be withdrawn from circulation and website locations may change.

Textbooks

There are no textbooks which cover the specific topics in this unit. However, the following may be useful.

Chapman C — *Resistant Materials (Real-world Technology)* (Collins, 2002) ISBN 0007115326

Norman E et al — *Advanced Design and Technology* (Longman, 2000) ISBN 0582328314

Timings R L — *Fundamentals of Engineering* (Longman, 1998) ISBN 0582305837

Websites

www.chemistry.about.com	
www.corrosion-doctors.org	
www.en.wikipedia.org	The Wikimedia Foundation
www.howstuffworks.com	
www.tangram.co.uk	Tangram Technology Ltd *(gives practical applications of polymers)*
www.twi.co.uk	The Welding Institute

Videos

A range of relevant video material can be obtained from:

American Technical Publishers Ltd, 27-29 Knowl Piece, Wilbury Way
Hitchin, Hertfordshire, SG4 0SX
Web: www.atplearning.com
Telephone: 01462 437 933

BBC Videos for Education and Training
Web: www.bbcactive.com
Telephone: 0845 313 9999

Classroom Video
Web: www.classroomvideo.co.uk
Telephone: 0117 929 1924

TV Choice Ltd
Web: www.tvchoice.uk.com
Telephone: 020 8464 7402

Other resources

Professional engineering journals

Engineering data handbooks and manufacturers' specifications

Unit 2: The Role of the Engineer

Internally assessed

Introduction

Human intervention and new technologies have significantly shaped the modern world. All manufactured objects around us have been engineered; from the transport systems that take us around cities to the mobile communications that help us keep in touch. The role of the engineer has increasingly involved the use of scientific, technical and mathematical knowledge to improve our lives.

In this unit you will investigate the role of an engineer when designing **and/or** manufacturing an engineered product **or** service. You will understand how new technologies, time and cost constraints, legislation and standards, and health and safety legislation influenced the engineering decisions made during the design **and/or** manufacture of an engineered product **or** service.

You will investigate the role of a professional engineer responsible for the design **and/or** manufacture of an engineered product or service you have decided to research.

Recommended prior learning

There is no specific prior learning recommended for this unit.

What you need to learn

2.1 Engineering activities

There are many and diverse branches of engineering disciplines; some of the most common are mechanical, electrical, electronic, civil, aeronautical, telecommunications, medical science, nano-technology and bioengineering.

Engineers working in these disciplines are part of a team responsible for the design, development and manufacture of engineered products or services.

You will choose an engineered product or service and investigate the role of an engineer who has contributed towards the design **or** manufacture of that engineered product.

You will study the role of the engineer, through the different activities the engineer is responsible for, in the design **or** manufacture of the engineered product or service.

You should be aware of the constraints the engineer has to consider when designing **or** manufacturing the engineered product or service. These constraints could be specific legislation and standards, health and safety or cost and time constraints.

2.2 The application of technology in engineering

Modern products, services and techniques do not only improve the lives of society in general, they also make the work of engineers more effective and efficient. Engineers must constantly be aware of developing technologies and be prepared to use them in their work.

In this unit you will investigate how the following appropriate technologies, relevant to your engineered product or service, have influenced the work of the engineer:

- CAD/CAM
- software applications
- control systems
- communications.

2.3 Legislation and standards in engineering

In a complex modern society it is essential to have a range of laws, codes of practice, contracts, procedures, and standards which govern the way engineers work.

In this unit you will investigate the importance of the appropriate legislation and standards, relevant to your engineered product or service, that influence the way the engineer works:

- how and why contract documents and procedures are used, eg contracts of employment, contracts to supply products and services, disciplinary procedures
- codes of practice that ensure that engineering activities are carried out safely and to the relevant standards, eg British and European standards
- specific standards that products or services must comply with before they can be offered for sale, eg Certification Europe (CE), British Standards Kitemark
- how the legal framework governing health and safety in all places of work affects engineers and engineering activities: eg, Health and Safety at Work Act 1974 (HSAW 1974), Control of Substance Hazards to Health (COSHH), Reporting of Injuries, Disease and Dangerous Occurrences Regulations 1995 (RIDDOR 1995), Electricity at Work Regulations 1989; Asbestos at Work Regulations 2002, Management of Health and Safety at Work Act 1999 (MHSW 1999).

2.4 Evaluation and modification

In this unit you will evaluate the engineered product or service you have investigated, to determine whether it is fit for purpose.

You will make suggestions for modifications, where appropriate, that will improve the design or performance of the engineered product or service. Proposed modifications can be presented in the writing of words, diagrams or as sketches/drawings.

Assessment evidence

Your portfolio should contain evidence of work carried out in response to your investigation into the role an engineer has in the design **and/or** manufacture of an engineered product **or** service.

You will investigate either the design of an engineered product **or** service **and/or** the manufacture of an engineered product **or** the implementation of a service.

Your work must include evidence of:

(a) the activities undertaken by the engineer in the design **and/or** manufacture of the engineered product **or** service

(b) current available technologies used by the engineer including why they were selected as being appropriate to the process

(c) how appropriate legislation and standards influenced the design **and/or** manufacture of the engineered product **or** service

(d) how appropriate health and safety standards used by the engineer influenced the design **and/or** manufacture of the engineered product **or** service

(e)* evaluation of the performance of the engineered product **or** service you have investigated for its being fit for purpose

(f) suggestions for possible modifications to improve the performance outcome of the engineered product **or** service.

* Opportunity for learners to be assessed on Quality of Written Communication (QWC) — (i-iii).

Assessment criteria

	Mark band 1		Mark band 2	Mark band 3	Mark awarded
(a) **(AO2)**	• Identifies an activity taken on by the engineer with little or no reference to the engineered product or service. **(0–2)**	• Identifies some specific activities taken on by the engineer with some reference to engineered product or service. **(3–4)**	• Identifies and describes some relevant activities taken on by the engineer that are specific to the engineered product or service. **(5–6)**	• Identifies, explains and justifies in detail most of the activities taken on by the engineer that are specific to the engineered product or service. **(7–8)**	**8**
(b) **(AO2)**	• Identifies a technology used by the engineer but is general with no explanation on why it was selected. **(0–3)**	• Identifies some general technologies used by the engineer with simple explanation of why they were selected. **(4–6)**	• Identifies and describes some specific technologies used by the engineer and explains why these technologies were used. **(7–9)**	• Identifies and describes most of the specific technologies used by the engineer. Explains with justifications why these technologies were used. **(10–12)**	**12**

	Mark band 1		Mark band 2	Mark band 3	Mark awarded
(c) (AO2)	• Identifies one relevant item of legislation that influenced the design and/or manufacture of the engineered product or service. • Identifies one relevant standard that influenced the design and/or manufacture of the engineered product or service. **(0-2)**	• Identifies some relevant items of legislation that influenced the design and/or manufacture of the engineered product or service. • Identifies some relevant standards that influenced the design and/or manufacture of the engineered product or service. **(3-4)**	• Identifies and explains how some of the relevant legislation influenced the design and/or manufacture of engineered product or service. • Identifies and explains how some of the main relevant standards influenced the design and/or manufacture of the engineered product or service. **(5-6)**	• Identifies and explains in detail how some of the main relevant legislation influenced the design and/or manufacture of the engineered product or service, including how to ensure compliance and the possible consequences of non-compliance. • Identifies and explains in detail how some of the main relevant standards influenced the design and/or manufacture of the engineered product or service, which would include how the engineer ensured that appropriate standards were met. **(7-8)**	**8**
(d) (AO2)	• Identifies one relevant health and safety standard that influenced the design and/or manufacture of the engineered product or service. **(0-2)**	• Identifies some relevant health and safety standards that influenced the design and/or manufacture of the engineered product or service. **(3-4)**	• Identifies and explains how some of the relevant health and safety standards influenced the design and/or manufacture of the engineered product or service. **(5-6)**	• Identifies and explains with reasons how some of the main relevant health and safety standards influenced the design and/or manufacture of the engineered product or service, including how the engineer ensured that appropriate standards were met. **(7-8)**	**8**

	Mark band 1		Mark band 2	Mark band 3	Mark awarded
(e)	• Evaluation is superficial and subjective, limited to general statements that are unsubstantiated and that do not consider fitness for purpose.	• Evaluation statements relate to most aspects of form and function but most points are unsubstantiated. Personal judgements lack objectivity, but with some consideration of fitness for purpose.	• Evaluation is through personal judgements and the results of some testing to determine fitness for purpose. Some statements are objective and supported by evidence and relate to more than one aspect of the intended use of the engineered product or service.	• Evaluation shows evidence of the use of some testing and relates to the engineered product or service fitness for purpose and intended performance. Most statements are objective and supported by evidence. Third party evaluation may be included.	
(AO3) **QWC (i-iii)**	• Uses everyday language and the response lacks clarity and organisation. Spelling, punctuation and the rules of grammar are used with limited accuracy.	• Uses everyday language but there are occasional uses of specialist vocabulary. The response lacks clarity and organisation although some attempt at focus is evident. Spelling, punctuation and the rules of grammar are used with occasional accuracy.	• Uses some specialist terms and the response shows some focus and organisation. Spelling, punctuation and the rules of grammar are used with some accuracy.	• Uses appropriate specialist terms consistently and the response shows good focus and organisation. Spelling, punctuation and the rules of grammar are used with considerable accuracy.	
	(0-4)	**(5-8)**	**(9-12)**	**(13-16)**	**16**

	Mark band 1		Mark band 2	Mark band 3	Mark awarded
(f) **(AO3)**	• Suggestions for modifications are superficial and cosmetic, and do not offer any improvement in the intended performance of the engineered product or service. **(0–2)**	• Suggestions for modifications are simplistic and lacking in detail, and are unlikely to improve the performance of the engineered product or service significantly. The suggestions are based on evaluation statements. **(3–4)**	• Suggestions for modifications are offered, each originating from a different statement of evaluation and containing enough detail to show how these will improve the performance of the engineered product or service. **(5–6)**	• Suggestions for modifications, each originating from a different statement of evaluation and containing the necessary detail to show how each of these will improve the performance of the engineered product or service. Includes reasoning to justify each proposal. **(7–8)**	**8**
				Total marks	**60**

(For description of AOs see *Performance descriptions* in *Appendix B*.)

Assessment guidance

When marking learners' work, you need to award individual marks for each assessment criteria. Using the *Assessment criteria* grid on pages 22-25, determine for each criterion the mark band in which the learners work most comfortably sits in. For mark band 1 we have subdivided the range to allow for an easier decision. A learner should be awarded the lower range of a particular mark range if they partially meet the statement. The upper range from that mark band should be awarded for the learner who is clearly within that statement and does not meet any of the statement from the above mark band. If you feel that the learner's work is actually fulfilling the next higher mark band range, then you need to repeat this process until you are happy you have decided on the correct mark band and the actual mark to be awarded.

For further guidance please refer to page 90 *Grading information*.

You should record your individual marks for each criteria for each learner using the Unit 2 Mark Record Sheet in the Edexcel GCE in the Engineering Teachers' Guide.

When submitting work for moderation, you must make sure that the mark record sheet is accompanied with the learner's work including witness statements where appropriate.

Delivering this unit

General

The delivery of this unit will require careful planning. Delivery needs to ensure that the subject matter is delivered in an interesting and stimulating way to reflect the regulations and standards to which engineers have to work.

Contact with industry is critical to the successful and effective delivery of this unit.

Care should be taken to ensure that a range of industrial practices is covered so that the subject matter of this unit is related to engineering practice in a wide range of engineering branches. It is essential that the delivery of this unit does not focus solely on its relevance to one single branch of engineering.

Careful consideration should be given to the requirements of the assessment criteria/criterion in order to ensure that it is possible for learners to achieve the full mark range.

Roles of engineers

The Engineering Council divides engineers into three specific categories: Chartered Engineer, Incorporated Engineer and Engineering Technician. Not all branches of engineering or all engineering employers use these categories, but they are a useful benchmark with which to compare real roles.

- Chartered Engineers are characterised by their ability to develop appropriate solutions to engineering problems, using new or existing technologies. Engineers are variously engaged in technical and commercial leadership and possess effective interpersonal skills.
- Incorporated Engineers maintain and manage applications of current and developing technology, and may undertake engineering design, development, manufacture, construction and operation. Incorporate Engineers are variously engaged in technical and commercial management and possess effective interpersonal skills.

- Engineering Technicians are involved in applying proven techniques and procedures to the solution of practical engineering problems. They carry supervisory or technical responsibility, and are competent to exercise creative aptitudes and skills within defined fields of technology. Professional Engineering Technicians contribute to the design, development, manufacture, commissioning, operation or maintenance of products, equipment, processes or services.
- Other skilled staff may operate equipment such as lathes and many 'crafts' or 'trades people' use a range of skills to require manual dexterity or hand tool skills.

This should be delivered by asking practising engineers to talk about their work role, looking at real job descriptions and visiting workplaces to see engineers 'in action'. A preliminary discussion with the engineers would help understand what it is that is needed to help the learners work towards their qualification.

At each stage, learners should be encouraged to analyse the work that particular people are carrying out, what level of engineering employee this work relates to and the levels of responsibility involved. It will become clear that the list of definitions given above differs in interpretation and that the categories actually tend to blend into each other rather than being specific steps.

Design process

In this context, the design process refers to the work that an engineer, who works in a design function, actually undertakes.

Implementation

Covers all aspects of engineering that are not specifically related to the design work, for example maintenance, production.

Environmental issues

An introduction to the topic should be provided to alert learners to the issues of the environmental effects caused by engineering activities. These are wide ranging from potential pollution to the surrounding countryside and waterways and air pollution, to noise pollution from machinery and transportation.

There are numerous examples of historical damage which could be used such as spoil heaps and subsidence produced by deep coal mining, the damage to the land caused by coal gas production and other past industrial processes. Throughout the Industrial Revolution, a high chimney was believed to get rid of pollution and smoke. Wind and air movements towards Scandinavian countries resulted in acid rain and the many problems associated with it. The modern engineer tries to help prevent a similar occurrence in the future.

Current issues could include the way in which regulations have been used to limit the damage to the environment and to people's health. For example the painting of cars. Regulations prevent the discharge of the volatile chemicals and paint dust into the atmosphere, requiring expensive filters, and require painters to wear full respiratory equipment fed with clean air from outside the workspace. Explanations of how developments have led to new water-based paint systems that reduce these issues could be used to brief learners in the sort of issues they need to consider. An alternative approach is to use automation, such as intelligent robots which can 'learn' how to spray a car body by being numerically or physically programmed, by an engineer.

It is important that the delivery of this section is set in the context of real engineering activities and, again, visiting speakers, and industrial visits can be valuable activities. It will not be possible to cover the requirements or to provide effective learning opportunities by relying on internet searches alone, although this is a useful resource for initial or follow-up information gathering.

The use of examples that learners analyse for themselves is important. Simple ideas can generate complex discussions, for example: the roadway or access to the college or school — how safe is it? Could it be improved? What resources and information would be needed?

Or, the disposal of waste concerns us all. What material is currently thrown away which could be re-cycled, or even managed without in the first place? For example as multiple fancy wrappings on products, tins, paper, cellophane etc. Or, are there any local derelict buildings which have not yet been converted into something useful, such as living accommodation?

We are surrounded with examples of engineering activities in different stages of progress and many which have yet to be seen by potential engineers' eyes.

Application of technology

The use of technology has dramatically changed the work of engineers over the last 30 years. Before this the only calculating devices available to the engineer were logarithmic tables, slide rules and very slow mainframe computers which were laboriously programmed using stacks of cards. A visit to the Science Museum may be beneficial and would help to explain this.

Now all engineers have access to a desktop computer that has the power to analyse designs and solve complicated calculations at high speeds. It is the positive effect on working practices that has resulted from such advances that is the essence of this section.

Particular examples include the use of computer aided drawing (CAD) software to produce designs that can easily be manipulated and modified. The engineer can use software to analyse these designs or to predict how a circuit will work under a variety of conditions or stress analysis in order to determine whether a component is strong enough to do its intended job. Electronic Workbench and other electronic circuit design software can predict the performance of particular circuit designs before they are built. The introduction of such software packages is recommended since many learners are very computer literate and can quickly learn to use the packages, or the manufacturers' free samples and demonstration packs, without instruction from teaching staff.

Developments in electrical communications mean that data can usually be transferred accurately and efficiently between designer and manufacturer, even between different countries. The increased use of computer aided manufacture (CAM) involving computer numerically controlled (CNC) machinery has led to the mass production of many high quality products to highly repeatable standards and tolerances.

All of these concepts should be demonstrated using real-work examples, classroom demonstrations, and discussions. There is an opportunity for visiting speakers to explain how they work, for visits to see engineers working and to question them about their work, as well as for classroom demonstrations using school-based or college-based IT facilities.

Many aspects of engineering appear regularly in newspapers or on TV. These can lead to good discussion topics and increase the interest of learners as it is happening before their eyes and all around them.

Standards and legislation

This section requires access to examples of documents from engineering workplaces. Samples of contract documents may be obtainable from companies, along with examples of procedures. There is no need to use actual contracts, just typical examples of documents that can, in effect, be the templates used by companies. Most companies will appreciate their confidential matters being treated as such and at the least any material used should be made anonymous. Some of the procedures and documents are generic and examples of contracts used by your school or college may also be worth considering. All schools and colleges have procedures in place and these are, in the main, public documents available on demand. They also make good teaching resources, as does your board of governors. Many industrialists and engineers are members of governing bodies and will be only too glad to help, either personally or by making recommendation of whom to contact. They will do this to demonstrate their involvement and monitoring of the processes taking place in the school or college. Procedures used in dealing with employment may also be generic. Many suppliers print their contract-supply-details on the reverse of their invoices and these may also be relevant.

Code of Practice (or ACOPs — Approved Codes of Practice)

This requires learners to relate real work situations to the Codes of Practice used by engineers. Exemplar codes of practice could be introduced in a general way with reference to the work situation. For example, codes of practice that relate to gas installations and electrical wiring, and how they relate to plumbers and electricians respectively. Many codes of practice are available free from the health and safety executive, or downloadable from www.hse.gov.uk.

Legislation

Articles of legislation are constantly changing. The best way of delivering this is to relate the real working environment to the legislation with, perhaps, a guest speaker from industry explaining how their work is affected by current and new legislation. This is possibly another role for a member of the governing body, or a partnership with another school or college.

Risk assessment

There are standard forms and procedures used by the Royal Society for the Prevention of Accidents (ROSPA) that could guide the delivery of this section. It is important for learners to identity risks when undertaking practical tasks. This can be carried out and well documented to industry standards by using the downloadable (free) publication from the Health and Safety Executive (HSE). This is called ‘5 steps’ and is easily found on www.hse.gov.uk. Similarly, www.direct.gov.uk is a massive source of information relating to everything for which the government is responsible.

It is important that learners examine and discuss these documents with a view to understanding the purpose that the documents serve — why do they exist?

Links

Other units

This unit provides knowledge and understanding that underpins *Unit 3: Principles of Design, Planning and Prototyping* and *Unit 6: Applied Design, Planning and Prototyping*, which cover design and project management. The influence of regulations and codes, environmental concerns and the use of technology all affect the work that that is carried out in these units.

This unit provides underpinning knowledge and understanding which is built upon in *Unit 5: The Engineering Environment*.

Industry

This unit is about industrial practice and, as such, requires the support of industry for its successful delivery. Examples of documents and procedures from industry will be valuable resources for use in delivering this unit.

Resources

Please note that while resources are checked at the time of publication, materials may be withdrawn from circulation and website locations may change.

Textbooks

There are no textbooks which cover the specific topics in this unit. However, the following may be useful.

Curtis A — *Business and Marketing for Engineers and Scientists* (McGraw-Hill, 1994) ISBN 0077078683

Hunt J E — *Business and Commercial Aspects of Engineering* (Butterworth-Heinemann, 1997) ISBN 0340676671

Tooley M and Dingle L — *Higher National Engineering* (Newnes, 2004) ISBN 0750661771

Websites

www.bsigroup.com	The British Standards Institution
www.cetechnologies.co.uk	CE Technologies Ltd
www.environment-agency.gov.uk	The Environment Agency
www.lsis.org.uk	The Learning and Skills Improvement Agency
www.theiet.org	The Institution of Engineering and Technology

Videos

Relevant video material can be obtained from:

American Technical Publishers Ltd, 27-29 Knowl Piece, Wilbury Way
Hitchin, Hertfordshire, SG4 0SX
Web: www.atplearning.com
Telephone: 01462 437 933

BBC Videos for Education and Training
Web: www.bbcactive.com
Telephone: 0845 313 9999

Classroom Video
Web: www.classroomvideo.co.uk
Telephone: 0117 929 1924

TV Choice Ltd
Web: www.tvchoice.uk.com
Telephone: 020 8464 7402

Unit 3: Principles of Design, Planning and Prototyping

Internally assessed

Introduction

Engineers are problem solvers. They are given a specification from a client, which they develop into a practical product or service using their technical knowledge and understanding to obtain an optimum design solution.

You will learn how to read, interpret and understand engineering drawings and how to generate your own. You will then use a given client brief to produce a design solution and plan an engineered project that includes the manufacture of a prototype. You will report back to your peers about the project in the form of a short oral presentation.

Recommended prior learning

There is no specific prior learning recommended for this unit although it is recommended that it is studied in parallel with:

Unit 1: Engineering Materials, Processes and Techniques

Unit 2: The Role of the Engineer.

What you need to learn

3.1 Engineering products

In this unit, you will focus on the principles of engineering design, planning and prototyping. You will design and manufacture an engineered product. The engineered product can be electrical, mechanical, fluidic, electronic or even a combination of these.

3.2 Engineering drawings

You will learn to read and interpret a range of engineering drawings and diagrams.

You will learn to produce engineering drawings using the appropriate current industry standards and conventions, either using IT-based systems such as Computer Aided Design (CAD) or manually. Your portfolio must include the following conventions:

- standard drawing sheets showing frame, title block and other markings
- recommended scales
- standard line types and thickness
- leader lines, arrows and dimensions
- sections and hidden details
- first or third angle projection
- pictorial drawings — isometric or oblique.

3.3 Project planning

You will learn to apply the following techniques when planning a project:

- identifying tasks
- producing an outline plan
- using planning tools such as Gantt charts
- progress checking.

3.4 Design

You will study the design process in terms of:

- understanding and interpreting a client brief given to you
- creating a specification that converts the client brief into technical terms with numerical values for relevant parameters
- producing at least **two** potential design solutions
- producing a final design solution that satisfies the requirements of the client brief.

Understanding the client brief

In order to begin developing ideas you must identify the key requirements from the client brief that will be given to you. The term 'client' implies a 'source' for generating an appropriate brief, and this could be a teacher, learner or any other appropriate individual or agency.

These key requirements should be in terms of:

- the function of the product
- what it should look like
- the materials it should be made from
- the technology necessary to produce it
- costs
- number required
- completion date.

Wider implications need to be considered in terms of:

- scale of production and the implication for manufacturing methods
- health and safety issues
- quality.

Creating a technical design specification

You will learn how to convert the client brief into a design specification. This will involve translating your understanding of the constraints imposed by the client brief into engineering information. This will include:

- function — this will involve specifying how the system works and within what parameters. For example, a radio can receive only a limited range of frequencies. A speedometer will have accuracy, a minimum speed it can detect and a maximum speed it can detect. What are these values?

- form and size — how big and heavy is the device to be? What shape is it to have? For example, a hand-held device must be big enough to handle without it slipping through fingers, yet not so big that it cannot be held comfortably. It cannot be so heavy that it cannot be held for long. These sizes and weights need to be stated as maximum and minimum values
- material requirements — what are the properties required of the materials that the prototype is to be manufactured from? If the prototype needs to be very strong then it may need to be made of metal. The choice of metal will depend on the required numerical values for strength, which are in the technical design specification.

Producing initial design ideas

In developing your ideas, and before turning them into possible design solutions, you need to use development techniques such as:

- brainstorming
- freehand sketching
- research; for example into existing products or services, materials available, how the required product or service might work.

The next stage in the design process requires a number of outline solutions to the design problem to be created. You need to produce at least **two** design solutions that are **significantly** different. Perhaps they use different operating principles, are made from very different materials, or are to be manufactured in different ways.

You will also identify production constraints for your design ideas, showing consideration for health and safety issues, in terms of:

- technology — traditional or computerised systems such as CNC, CAD and CAM
- materials — the influence of physical and mechanical properties in relation to manufacturing methods
- availability of resources — labour, materials, and equipment
- environment — consideration of the environment in which the product or system is used to minimise problems such as noise and pollution.

Formative evaluation

You will then choose the best features of your initial designs for further development, and these will be used in your final design solution. To do this, you should assemble a panel (peer review) of colleagues who will evaluate your initial ideas against your specification. You will then be able to use this formative evaluation to help you proceed towards a final design solution.

Producing a final design solution

You will carry out the detailed design and development of your final design solution. The final design will be defined by a set of engineering drawings and materials and components lists. Your drawings will incorporate, or be supplemented by, design notes that explain how the design operates, and how it is to be manufactured.

Where numerical values are included as part of the proposed solution, you should show how you applied your scientific and mathematical understanding to arrive at your outcome. Where materials are selected for use because of their scientific properties, you should show any relevant scientific and mathematical data you used in selecting the material.

Communicating your designs

In order to be able to communicate your final design solution, you need to be able to produce technical drawings, either using appropriate computer-based graphical software or manually, that conform to appropriate industry standards and conventions. Depending on your design solution, you may need to produce the following types of drawing:

- freehand sketches
- general arrangement drawings
- detail drawings
- circuit diagrams
- flow diagrams
- schematic diagrams.

You will develop and demonstrate a working knowledge of an appropriate sub-set of national standards and conventions, as used in a particular sector of engineering.

3.5 Manufacturing a prototype

You will now have an opportunity to try out your skills by producing a prototype based on the final design solution.

A prototype is a first attempt at a representative-working product. Its primary function is to prove the design principles and to demonstrate how the product will look and function.

You must consider health and safety legislation at all appropriate stages of manufacture.

You do not need to carry out advanced engineering procedures. However, you will need to manufacture some form of prototype which can demonstrate that your final design solution will work. You do not have to manufacture a working product to industrial standards to gain a good mark in this unit. You may have assistance from a technician to make technically complex or difficult components, but their contributions must be identified in your work.

3.6 Project presentation

You will provide a project presentation to your peers. The presentation should summarise the activities undertaken during the design and manufacture of your engineered product.

You will demonstrate good communication skills including the use of appropriate technical vocabulary. Your communication will be presented in a logical and well-organised manner that enables you to explain and communicate the important features of your project.

The use of IT resources, such as PowerPoint or Word will enhance your presentation.

Assessment evidence

Your portfolio should contain evidence of your work carried out in the design, development and manufacture of an engineered product.

You will submit your work on A4 apart from the engineering drawings that will be submitted on A3 paper. You will also include photographic evidence of your final prototype and a copy of your presentation material(s). Your teacher will complete a witness statement detailing the quality of your oral presentation.

Relevant health and safety issues should be addressed throughout your portfolio.

Your work must include evidence of:

(a) a portfolio of engineering drawings

(b) project planning and a design specification that meets the client brief

(c)* initial design ideas and their development that have been evaluated against the requirements of the client brief leading to the final design solution

(d) a prototype which demonstrates the effectiveness of your final design solution

(e) a presentation of your project.

* Opportunity for learners to be assessed on Quality of Written Communication (QWC) — (i-iii).

Assessment criteria

	Mark band 1		Mark band 2	Mark band 3	Mark awarded
(a) (AO1)	• An engineering drawing with use of an industry standard symbol and an appropriate drawing convention. **(0–2)**	• A range of recognisable engineering drawings with limited use of industry standard symbols and a limited range of appropriate drawing conventions. **(3–4)**	• A range of engineering drawings containing sufficient information to manufacture most parts of the product. The drawings display the correct selection and use of some appropriate industry standard symbols and conventions. **(5–6)**	• A range of engineering drawings that contain a majority of detailed information needed to manufacture the design solution. The drawings make appropriate use of most of the industry standard symbols and conventions necessary to manufacture the design solution. **(7–8)**	**8**
(b) (AO2) (AO3)	• A production plan with reference to a process, but no reference to time and resources. • A superficial specification with limited points that lack detail relevant to the customer brief. **(0–2)**	• A production plan with reference to some processes, but no reference to time and resources. • A specification that considers a range of points but is general and could be applied to many other customer briefs/products. **(3–4)**	• A production plan that considers the main processes with some realistic deadlines and appropriate resources taken into account. • A technical specification that is directly relevant to the engineered product containing some important points that can be evaluated against the customer brief. **(5–6)**	• A clear and detailed production plan that considers the main manufacturing processes in the correct sequence with relevant and achievable deadlines taken into account. • A detailed and relevant technical specification addressing most important points that are qualified by further information and which contains quantitative information that can be evaluated against the customer brief. **(7–8)**	**8**

	Mark band 1		Mark band 2	Mark band 3	Mark awarded
(c) **(AO3)** **QWC (i-iii)**	• Uses limited design strategies to generate some ideas that are similar. Limited use of research, which is general. Evaluation is subjective and superficial. No health and safety issues considered. • Uses everyday language and the response lacks clarity and organisation. Spelling, punctuation and the rules of grammar are used with limited accuracy. **(0-4)**	• Uses some design strategies to generate ideas that consider some points of the specification. Some use of relevant research. Evaluation is subjective, but is reviewed against the specification points. At least one aspect of health and safety is considered. • Uses everyday language but there are occasional uses of specialist vocabulary. The response lacks clarity and organisation although some attempt at focus is evident. Spelling, punctuation and the rules of grammar are used with occasional accuracy. **(5-8)**	• Uses a range of design strategies to generate ideas that consider points of the specification and differ from each other. Selects and uses appropriate research. Objectively evaluates ideas against specification points. Considers most relevant health and safety issues appropriate to the engineered product. • Uses some specialist terms and the response shows some focus and organisation. Spelling, punctuation and the rules of grammar are used with some accuracy. **(9-12)**	• Uses a diverse range of design strategies, considers alternative materials, processes and disciplines to generate and refine realistic design solutions that match the specification. Uses formative feedback to influence design solutions against specification points. Considers the impact of most health and safety issues with reasons for their relevance to the product. • Uses appropriate specialist terms consistently and the response shows good focus and organisation. Spelling, punctuation and the rules of grammar are used with considerable accuracy. **(13-16)**	**16**

	Mark band 1		Mark band 2	Mark band 3	Mark awarded
(d) **(AO3)**	• Some understanding of a limited range of materials, components and processes. Manufacturing skills show little attention to detail. The manufactured product matches more than one aspect of the final design solution but barely functions. Some general safety awareness displayed. **(0-5)**	• An appropriate understanding of a limited range of materials, components and processes; selection using appropriate scientific and or mathematical information. Adequate manufacturing skills that show some attention to detail. Parts and sub-systems fit together so that the product functions and meets some aspects of the final design solution. Some focused awareness of safe working conditions is displayed. **(6-10)**	• A good understanding of an appropriate range of materials, components and processes; selection and use based on appropriate application of scientific and/or mathematical information. Good manufacturing skills that demonstrate attention to detail. The product matches most aspects of the final design solution and functions well. Awareness of safe working conditions for most specific processes demonstrated. **(11-15)**	• Clear and detailed understanding of an appropriate range of materials, components and processes; selection and use justified using appropriate scientific and/or mathematical information. High-level manufacturing skills that demonstrate precision and attention to detail. The prototype fully matches the final design solution and functions as intended. High levels of awareness of safe working practices for all relevant processes are in evidence. **(16-20)**	**20**

	Mark band 1		Mark band 2	Mark band 3	Mark awarded
(e) **(AO3)**	• A presentation with little preparation, demonstrating adequate communication and presentation skills, using limited specialist vocabulary. Limited use of IT. **(0–2)**	• A presentation appropriately planned, using adequate communication and presentation skills including some specialist technical vocabulary that conveys sufficient relevant information to identify some features of the project. Some appropriate use of IT. **(3–4)**	• A presentation demonstrating clear communication and presentation skills including specialist technical vocabulary. Organised in the correct sequence to convey some of the most important features of the project in a relevant and coherent manner. Skilful use of IT. **(5–6)**	• A presentation, using high quality communication and presentation skills, that demonstrates the use of specialist technical vocabulary. Communicated in a logical and well-organised manner to successfully explain the main features of the project. Skilful use of IT. **(7–8)**	**8**
				Total marks	**60**

(For description of AOs see *Performance descriptions* in *Appendix B*.)

Assessment guidance

When marking learners' work, you need to award individual marks for each assessment criteria. Using the *Assessment criteria* grid on pages 36-39, determine for each criterion the mark band in which the learners work comfortably sits. For mark band 1 we have subdivided the range to allow for an easier decision. A learner should be awarded the lower range of a particular mark range if they partially meet the statement. The upper range from that mark band should be awarded for the learner who is clearly within that statement and does not meet any of the statement from the above mark band. If you feel that the learner's work is actually fulfilling the next higher mark band range, then you need to repeat this process until you are happy you have decided on the correct mark band and the actual mark to be awarded.

For further guidance please refer to page 90 *Grading information*.

You should record your individual marks for each criteria for each learner using the Unit 3 Mark Record Sheet in the Edexcel GCE in the Engineering Teachers' Guide.

When submitting work for moderation, you must make sure that the mark record sheet is accompanied with the learner's work including witness statements where appropriate. You must provide a witness statement, for each learner, detailing the quality of their oral presentation.

Delivering this unit

General

The delivery of this unit will require careful planning. Delivery needs to ensure that the subject matter is delivered in an interesting and stimulating way.

Contact with industry is critical to the successful and effective delivery of this unit.

When considering the engineered product to be designed and manufactured, careful consideration should be given to the requirements of the assessment criteria/criterion in order to ensure it is possible for learners to achieve the full mark range.

Client brief

You should generate the client brief for the learner or it can be generated by another source identified by the learner.

The client brief must be a clear description of the problem the learner will solve. The brief will include the recognition of a problem, identification of needs and enough information to place the problem into context. The information included in the brief will be simple, focused and concise, giving direction to the learner. It will not be so precise as to leave no room for development of their ideas by imposing unnecessary constraints on any proposed design solutions they may produce.

Engineering systems and drawings

Learners should be provided with any systems diagrams appropriate to their needs, selected from a range of engineering disciplines, including electrical/electronic, mechanical and fluidic systems.

Learners should be taught how to create formal technical drawings and pictorial sketches to communicate their ideas. They should be encouraged to use manual and IT-based drawing techniques, where appropriate. Learners should be familiar with, and apply, industry standard symbols and drawing conventions where appropriate.

Learners will be required to produce a portfolio of drawings that demonstrates their skills and understanding of engineering systems. The portfolio should consist of notes and sketches in A4 format and formal engineering drawings produced to A3 scale.

Project planning

Learners should be taught to plan a project based on a given client brief and their resulting design solution. Learners should design a production plan that includes reference to tasks, time, materials, processes and quality control points.

Engineered product

Definition:

In this context the term 'engineered product' may be interpreted to include:

- a physical product, for example an item of mechanical, electronic, fluidic equipment
- a service product, for example, a dial-up data or voice communications service
- a 'system' product, for example, a specialised computer database or software application.

Selecting a project

Learners are required to undertake a project leading to the manufacture of an engineered product, based on a detailed client brief.

In selecting a suitable project the following points should be borne in mind.

- The starting point for a project should be the client brief, which should be open ended enough to offer learners the opportunity to explore a number of alternative ideas, without pre-empting any proposed solutions.
- The project brief should provide appropriate levels of demand for individual learners and offer access to the full range of marks in each assessment criteria.
- When working towards an outcome, learners should be encouraged not to be over-ambitious or to take on over-demanding tasks for the time and resources available for their levels of knowledge, skills and understanding.
- In practice, projects leading to 'service' products are likely to be more challenging to learners and centres, because of difficulties in the research and product implementation ('manufacturing') phases of the project.
- The most appropriate and sustaining projects are those that arise out of realistic and relevant requirements, and which can be trialled under real-world conditions when completed.

Design

Learners should be presented with a client brief. The term 'client' implies a 'source' for generating an appropriate brief and could include a teacher, a learner or any other appropriate agency.

The learner should be encouraged to discuss with the client the requirements to establish the key features of the brief. The agreed client brief should reflect the resources available, as learners will manufacture a prototype using these resources.

At this point, learners should pursue the design route detailed in Section 3.4 on page 32 to design and develop a proposed solution that satisfies the requirements of the client brief. Appropriate drawings and notes should be produced by the learner in order to communicate design ideas and their development in detail and to demonstrate how the final design solution meets the client brief.

During their design activities, learners should be encouraged to seek research from a wide range of sources. This may include product analysis of similar products/systems, interviews with experts and market research to establish the market potential of the proposed product/system.

At appropriate points in the design and development of the project, learners should meet with the 'client' or potential user group (selected from the peer group) to gain feedback on progress to date and to use this formative evaluation to influence future developments of the project.

Where possible, learners should be encouraged to make contact with professional engineers and to make visits to manufacturing industry in order to broaden their experience and understanding of real-world engineering.

As design details are developed, learners should be encouraged to record any scientific data they use in their designs. For example, selecting materials for their particular properties of compressive or tensile strength, their conductivity, malleability etc.

Any mathematical formulae used to resolve problems during designing should be illustrated and explained.

Relevant health and safety considerations should be recorded at appropriate stages in the design/development of the engineered product.

When selecting materials for use in the final design solution, learners should be encouraged to use their knowledge and understanding of materials science gained from their study of *Unit 1: Engineering Materials, Processes and Techniques*.

Manufacturing a prototype

Learners should have access to appropriate workshop facilities to manufacture a prototype that meets the requirements of their final design solution.

Witness statements and photographic evidence should be used to provide evidence of safe, correct and competent use of appropriate tools, equipment, techniques and processes.

Clear photographic evidence of the final manufactured product must be in evidence.

Learners should be encouraged to record any calculations they use, for example to determine component values used during the manufacture of their prototype. Evidence of any measuring and testing equipment and any data collection relevant to their work should also be recorded.

An awareness of relevant health and safety considerations should be evidenced using the witness statement in *Appendix C*.

Casing

It is important to strike a balance between the amounts of effort applied to the 'technology' content of a project and that directed to the use of materials to produce a case in which to hold electronic circuitry or a mechanical system. It is not appropriate to allow learners to spend the majority of their time on designing, developing and manufacturing a high quality case and then using a 'found' circuit or system that is not understood or personalised in any way.

Engineering work should be dominated by the knowledge and understanding related to the technology involved in it and evidence of this should be present throughout the portfolio. Design and development of the casing should be of secondary importance. As a general guide, learners should divide their efforts in a ratio of about 70:30 in favour of the technological content of their work. A learner, who presents high quality designing and manufacturing skills for the case and simplistic, low-level 'technology' work, will not score in the high categories of assessment. However, a learner who produces a complex and successful solution to a challenging technological problem, but manufactures a simple, undemanding case that is poorly finished can still achieve marks in the higher categories of assessment.

Mechanisms project work will, by its nature, require more use of materials to construct structures in which to house mechanical systems, but the portfolio must reflect the focus on technological content described previously.

Photographic evidence

It is essential that high quality photographic evidence is presented in support of learners' work, but it is not acceptable to simply photograph the external casing of a product without adding important details to accompany this general view.

Where electronic circuitry is included in a project, photographs must show a learner's skills in electronic manufacturing. This should include details of quality of soldering, how flying leads are dealt with, how exposed wires and switch contacts are insulated, how batteries are secured and accessed and how circuit boards are anchored.

Close-up details of mechanical systems should be similarly photographed to support the levels of assessment awarded by centres.

Project presentation

Learners will need to provide a presentation of the project. Learners can do an oral presentation to a small audience or they could decide to do a multi-media presentation.

If learners want to present their presentation to a small audience, then access to appropriate IT resources will be beneficial. The use of outside agencies, such as industrialists, to provide feedback or help in preparation are likely to enhance the status of the presentation and help to encourage learners to achieve the highest level of communication skills.

A copy of the learner's presentation material(s) should be submitted as part of the learner's portfolio.

The quality of the presentation should be detailed using the witness statement in *Appendix C*.

Links

Other units

This unit will normally be delivered in conjunction with *Unit 1: Engineering Materials, Processes and Techniques* and *Unit 2: The Role of the Engineer*. Learners should use their knowledge of materials and processes to assist their project planning.

Industry

Visits to engineering design companies will help focus learners' ideas of projects and project management. A visiting industrialist, to occasionally monitor progress, will be of benefit, as will an industrialist to witness the final presentation and to comment on the written report.

Resources

Please note that while resources are checked at the time of publication, materials may be withdrawn from circulation and website locations may change.

Textbooks

There are no textbooks which cover the specific topics in this unit. However, the following may be useful.

Lester A — *Project Planning and Control* (Butterworth-Heinemann, 2005) ISBN 0750658436

McFarlane B — *Beginning AutoCAD 2002* (Butterworth-Heinemann, 2002) ISBN 0750656107

Simmons C and Maguire D — *Manual of Engineering Drawing* (Newnes, 2003) ISBN 0750651202

Websites

www.bsigroup.com	The British Standards Institution
www.semta.co.uk	Sector Skills Council for Science, Engineering and Manufacturing Technologies

Videos

A range of relevant video material can be obtained from:

American Technical Publishers Ltd, 27-29 Knowl Piece, Wilbury Way
Hitchin, Hertfordshire, SG4 0SX
Web: www.atplearning.com
Telephone: 01462 437 933

BBC Videos for Education and Training
Web: www.bbcactive.com
Telephone: 0845 313 9999

Classroom Video
Web: www.classroomvideo.co.uk
Telephone: 0117 929 1924

TV Choice Ltd
Web: www.tvchoice.uk.com
Telephone: 020 8464 7402

Unit 4: Applied Engineering Systems

Externally assessed

Introduction

Engineered products are many and varied. They range in complexity from everyday items such as bicycles and mobile phones to aircraft and space vehicles. It is often useful to think of these as engineering systems, each with its particular input and output. You will learn through investigation that the more complex products can usually be broken down into a number of interconnected sub-systems. These are often arrangements of mechanical, electrical and electronic components that enable the product to function and be controlled.

In this unit you will look at ways in which engineering techniques and principles are applied in some important systems and how a systems approach can be used to solve engineering problems. The range you will cover includes static structures, pneumatic systems and the electrical lighting and power systems used in homes, offices and public buildings. You will also look at elements of the electro-mechanical and electronic systems found in everyday life and the means by which they are controlled.

Recommended prior learning

Unit 1: Engineering Materials, Processes and Techniques

Unit 2: The Role of the Engineer

Unit 3: Principles of Design, Planning and Prototyping

External assessment

This unit is externally assessed and will be based on a practical activities brief set by Edexcel each year. This brief will be available on the Edexcel website in September in each examination year. The assessment will be available in the June examination series.

The number of raw marks available is 60.

You will have the opportunity to carry out relevant research based on the content of the brief before you carry out your practical activities.

Evidence to be assessed against this unit must be produced under examination conditions and meet the requirements of the brief.

You **cannot** take any of your research materials in with you.

Working under examination conditions, you will work independently to complete all three practical activities to fulfil the requirements of this unit.

You must complete all activities in 10 hours or less.

What you need to learn

4.1 Static structural systems

Roof trusses, the large cranes used on building sites and some bridges are examples of framed structures. It is important for engineers to know the forces acting in the structural members and the strength of the materials from which they are made.

Basic calculations

You will need to know how to calculate the tensile and compressive stress in structural members, the change in length caused by these stresses and the factor of safety in operation. The basic formulae for these are:

- Direct stress = Force/Cross-sectional area
- Factor of Safety = Allowable stress/Working stress
- Direct strain = Change in length/Initial length
- Modulus of Elasticity = Direct stress/Direct strain.

Tensile testing

You will need access to the following items of test equipment.

- Hounsfield tensometer or other tensile testing machine for carrying out destructive tests.
- Extensometer, incorporating a micrometer, vernier scale or dial-test indicator for recording changes in length.
- Standard test specimens for common structural materials.

You will need to know how the specimens are tested and how the recorded data is used to obtain the following:

- load v extension and stress v strain graphs
- ultimate tensile strength
- modulus of elasticity.

Framed structures

You will need to know the names of the different types of member in a framed structure. They are:

- ties
- struts
- redundant members.

You will not be expected to investigate structures with more than four members and you can assume that they are pin jointed at their ends. You may use a graphical or analytical method to determine the forces that are present. You will then be able to calculate:

- stress in members
- factor of safety in operation
- change in length of members.

4.2 Electro-mechanical systems

In electro-mechanical systems the inputs and outputs are electrical power and mechanical movement. They may be thought of as energy transfer and conversion systems. Many domestic appliances, power tools and items of office equipment contain electro-mechanical systems. Sometimes they incorporate pneumatic circuits. These use compressed air to transmit power and produce mechanical movement.

Basic calculations

You will need to be able to calculate force, work and power using the following basic formulae.

- Force = Pressure x Area
- Work done = Force x Distance moved
- Average power = Work done/Time taken
- Instantaneous power = Force x Instantaneous velocity
- Electrical power = Current x Voltage.

Electro-mechanical system elements

You will need to know how the following electrical and mechanical system elements operate and how they are used:

- d.c. motors
- a.c. motors
- stepper motors
- mechanical linkages, for example slider crank and four-bar linkages and inversions
- simple and compound gear trains
- belt and chain drives
- power transmission shafts.

Basic pneumatic equipment

You will be expected to know the symbols used in circuit drawings for the following components and explain the operation of a simple pneumatic circuit:

- compressor
- compressed air receiver
- pressure regulator
- single acting cylinders with spring return
- double acting cylinders
- control valves such as a 3 port (3/2) valve and a 5 port valve for bi-directional control with push-button or solenoid actuation.

4.3 Power and lighting systems

You should be familiar with the main requirements of a lighting and power system for your home or a small office or a workshop, using a single phase supply.

Basic calculations

You should be familiar with Ohm's law and be able to calculate:

- current and voltage in series and parallel circuits
- electrical power, ie Power = Current x Voltage
- running costs.

Lighting and power circuit components

You should know how the following components operate and their typical uses.

- tungsten filament lamps
- tungsten halogen lamps
- fluorescent tubes
- sodium lamps
- switches and dimmers
- sockets
- plugs.

Cabling and connections

You should be aware of the different types of cable used in lighting and power circuits and the ways in which they are connected. In particular you need to know about:

- cable capacities for power and lighting
- parallel wiring system for lamps
- simple on/off and the use of the two-way 'landing' circuit for switching lamps on and off
- ring main power circuits
- the importance of switching the 'live' conductor rather than the 'neutral', and the reasons for this.

Circuit protection

You should know about the ways in which lighting and power circuits are protected and made safe to use. In particular you should know the reasons for the use of:

- fuses
- Miniature Circuit Breakers (MCB)
- Residual Current Detectors (RCD)
- earthing for equipment with metal chassis, and how double insulation removes the need for an earth wire.

4.4 Electronics, instrumentation and control

Electronics, particularly the use of microelectronics, provide very sophisticated ways of monitoring and controlling a wide variety of equipment. A monitoring or measuring system usually comprises three major elements — a sensor or transducer, a signal conditioner and a display unit or recorder. It is useful to display the elements of a monitoring system in the form of a block diagram.

Sensors and transducers

You will need to know how the following sensors/transducers operate:

- thermocouples, resistance thermometers, thermistors and bi-metallic strips for sensing temperature change
- light-sensitive resistors for sensing changes in illumination

- piezo-electric devices and electrical resistance strain gauges for sensing force and pressure
- linear and rotary potentiometers for detecting changes in linear and angular displacement.

Signal conditioners

You will need to know how the following devices are used to change or modify the signal from a transducer into a more usable form:

- mechanical levers
- gear trains
- voltage amplifiers
- electrical noise filters
- Wheatstone bridge circuits
- analogue-digital converters.

Display units and recorders

You will need to have a general awareness of how the following items of display/recording equipment operate and how they are used:

- analogue scales and pointers, eg moving coil meter
- digital displays
- cathode ray oscilloscope
- visual display units (VDUs)
- chart recorders
- X-Y plotters
- data loggers.

A control system may be of the open-loop or closed-loop type. The closed-loop often incorporates a monitoring system, the signal from which is used to modify the system output. Control systems very often operate using a combination of analogue and digital signals. You should be able to explain the concept of using a computer to control an engineering process.

Reference sources

Measuring systems need to be calibrated. This involves checking them against a reference source that is known to have a higher degree of accuracy.

You will need to have a general awareness of the following reference sources:

- standard pressure gauges
- standard thermometers
- standard sources for voltage comparison, eg Cambridge potentiometer
- standard sources for current comparison
- signal generators, frequency references and cathode ray oscilloscope for frequency comparison, for example in the production of Lissajous figures.

Control systems

You will need to know the meaning of the following terms.

- open-loop control
- on-off closed-loop control
- hysteresis in on-off control systems, eg thermostat
- set point
- proportional closed-loop control.

Control elements

You will need to be aware of how the feedback signal in a closed-loop control system is compared with an input reference signal to generate a corrective error signal. You should have a general awareness of:

- comparators such as the potentiometer and operational amplifier
- Programmable Logic Controllers (PLCs) with an overview of ladder logic
- personal computers with additional I/O cards
- dedicated systems using a microprocessor or a Programmable Interface Controller (PICs).

Communication

You will need to know about the following methods of communication:

- electrical cables (plain two wire and coaxial)
- fibre optic cables
- radio waves
- optical and infrared beams.

You should be aware of how basic communication systems such as modems and cellular phones operate. In particular, you should know about:

- analogue and digital systems and conversion
- modulation and demodulation
- bandwidth.

4.5 Health and safety factors

Health and safety issues are a key consideration in the design and production of engineered products. For each of the systems areas you investigate you must be aware of the relevant health and safety factors and how these must be taken into account in the product design.

Assessment evidence

You will need to submit evidence of your work for each of the following practical activities using the brief given to you by your teacher.

Activity 1

(a) Measure and record the behaviour of a structural material when subjected to a destructive tensile test. Process the data and determine the tensile strength and modulus of elasticity of the material. Determine the internal forces present in a loaded-framed structure. Calculate the factor of safety in operation and the dimensional changes caused by the loading.

Activity 2

(b) Explain the function of a given electro-mechanical system.

(c) Investigate the sub-systems and elements that comprise the given electro-mechanical system. Describe using a block diagram, their function, relationships and the transfer or conversion of energy that might occur.

(d) Provide an alternative design solution that fulfils the basic functions of the system.

Activity 3

(e)* Respond to a design specification for a monitoring or control system by producing an appropriate and feasible design solution that takes account of its operational requirements and health and safety considerations.

(f) Select suitable materials and components for the design solution taking into account possible production and cost constraints and health and safety considerations.

* Opportunity for learners to be assessed on Quality of Written Communication (QWC) — (i-iii).

Assessment criteria

	Mark band 1		Mark band 2	Mark band 3	Mark awarded
(a) (AO1) (AO2)	• A limited understanding of using the equipment. Data is inaccurate **and** cannot determine tensile strength and modulus of elasticity. • Some aspect of structural loading determined but analysis is weak and incomplete. **(0-4)**	• Successful use of the equipment with reliable data extraction but with little understanding of processing the data to determine either tensile strength **or** modulus of elasticity. • Some structural loading correctly determined. **(5-8)**	• Successful use of the equipment with reliable data extraction to determine accurate tensile strength **or** modulus of elasticity. • All the main materials properties and effects of structural loading determined. **(9-12)**	• Successful use of the equipment with reliable data extraction to determine accurate tensile strength **and** modulus of elasticity. • Fully determines and evaluates the relevant materials and determines the full effects of the structural loading. **(13-16)**	**16**
(b) (AO1)	• A limited understanding of the electro-mechanical system. **(0-2)**		• Some understanding of the electro-mechanical system, with some aspects of the key functions explained. **(3-4)**	• Most aspects of the function of the electro-mechanical system understood and explained in detail. **(5-6)**	**6**
(c) (AO2)	• Block diagram contains only basic and general information and identifies some of the internal workings of the system. **(0-4)**		• Block diagram contains some relevant information with a broad explanation of the internal workings of the system. Some consideration of energy transfer within the system. **(5-7)**	• Block diagram contains most relevant information with a detailed explanation of the internal workings and energy transfer within the system. **(8-10)**	**10**

	Mark band 1		Mark band 2	Mark band 3	Mark awarded
(d) **(AO3)**	• Alternative design solution that partially meets the operational requirements, where the outcome is unlikely to function. **(0-2)**		• Alternative design solution is appropriate and meets some of the operational requirements, where the outcome could broadly functions. **(3-4)**	• A workable alternative design solution that meets most of the operational requirements and is likely to function. **(5-6)**	**6**
(e) **(AO3)** **QWC (i-iii)**	• Design solution is superficial and contains only a few specified requirements. A health and safety aspect is considered. • Uses everyday language and the response lacks clarity and organisation. Spelling, punctuation and the rules of grammar are used with limited accuracy. **(0-4)**	• Design solution is feasible and takes into account some of the specified requirements. Some health and safety aspects considered. • Uses everyday language but there are occasional uses of specialist vocabulary. The response lacks clarity and organisation although some attempt at focus is evident. Spelling, punctuation and the rules of grammar are used with occasional accuracy. **(5-9)**	• Design solution is feasible and takes into account most of the specified system requirements. Some relevant health and safety aspects are considered and explained. • Uses some specialist terms and the response shows some focus and organisation. Spelling, punctuation and the rules of grammar are used with some accuracy. **10-14)**	• Detailed workable design solution that takes into account most of the specified system requirements. Most relevant health and safety aspects are considered and explained. • Uses appropriate specialist terms consistently and the response shows good focus and organisation. Spelling, punctuation and the rules of grammar are used with considerable accuracy. **(15-18)**	**18**

	Mark band 1	Mark band 2	Mark band 3	Mark awarded
(f) **(AO1)**	• Materials and components identified and selected without consideration of production constraints, cost and health and safety issues. **(0–2)**	• Some appropriate materials and components selected, with some consideration of production constraints, cost and health and safety issues. **(3)**	• Most materials and components selected, with justification that includes a consideration of production constraints, costs and health and safety issues. **(4)**	**4**
			Total marks	**60**

(For description of AOs see *Performance descriptions* in *Appendix B*.)

Assessment guidance

When marking learners' work, you need to award individual marks for each assessment criteria. Using the *Assessment criteria* grid on pages 52-54, determine for each criterion the mark band in which the learners work comfortably sits. For some of the assessment criteria in mark band 1 we have subdivided the range to allow for an easier decision. A learner should be awarded the lower range of a particular mark range if they partially meet the statement. The upper range from that mark band should be awarded for the learner who is clearly within that statement and does not meet any of the statement from the above mark band. If you feel that the learner's work is actually fulfilling the next higher mark band range, then you need to repeat this process until you are happy you have decided on the correct mark band and the actual mark to be awarded.

For further guidance please refer to page 90 *Grading information*.

You should record your individual marks for each criteria for each learner using the Unit 4 Mark Record Sheet in the Edexcel GCE in the Engineering Teachers' Guide.

When submitting work for moderation, you must make sure that the mark record sheet is accompanied with the learner's work including witness statements where appropriate.

Delivering this unit

General

This unit is externally assessed and will be based on a brief set by us each year. The brief containing three practical activities will be similar each year but the topic/product selected will vary.

The brief will be available only from the Edexcel website (www.edexcel.com) and will be available from September for each year.

Learners should carry out relevant research on the content of the brief before they complete the activities. They cannot take any of their research materials in with them when completing their practical activities.

The three practical activities may be started at anytime after the brief has been published, at centre discretion.

Learners should spend no more than 10 hours in completing the three practical activities.

Working under examination conditions, learners will work independently to complete all three practical activities to fulfil the requirements of this unit.

A deadline date will be set and issued with the brief.

Assessment will be carried out by centre assessors, whose decisions will be subject to moderation by Edexcel's external moderators. For this purpose, Edexcel will require a sample of the learners' work and moderation will take place during the June examination series.

Learners' marks must be entered on the appropriate OPTEMS form and returned to Edexcel by the published deadline.

Teaching strategies

This unit aims to give a broad knowledge of a range of engineering systems. A range of teaching and learning methods may be used. Industrial visits and links with industry will be of value as will links with higher education institutions. A guided investigative approach should be adopted and, so far as health and safety regulations permit, learners should be given the opportunity for hands-on investigation. The use of block diagrams should be encouraged to illustrate the elements of a system, the way that they are interconnected and their inputs and outputs. Learners should be encouraged to compare the advantages and disadvantages of alternative structural systems, energy conversion systems and control systems.

Systems investigations

Access to equipment for material testing and a range of test specimens for common engineering materials is essential. The Hounsfield tensometer is ideal for this purpose but an opportunity to use or observe the use of industrial standard equipment should not be missed. It will also be beneficial if you are able to carry out investigations using commercially produced pneumatic teaching rigs.

A range of monitoring system elements should be investigated experimentally to provide experience of the building blocks that comprise these systems. Element sensitivities should be considered together with overall system sensitivity.

The practical operation of a thermostat might be studied as an example of on/off control and its hysteresis measured. It is also recommended that you construct a comparator circuit on a breadboard so that learners familiarise themselves with its operation as part of a closed-loop control system.

It is important that the learner appreciate the principles of computer control, but they are not expected to program a system (eg with ladder logic). An appreciation of analogue to digital conversion is needed but not the detailed circuitry. The way in which an analogue signal can be converted to digital, in order to use digital processing, and the importance of the sampling rate should be understood.

Lighting and power circuit calculations should be concerned primarily with current voltage and power in series and parallel connections and rating of cables, lamps and appliances. The resistivity of important conducting materials, such as copper, should be considered. It would also be useful to consider the resistance of the tungsten and alloy wire used in lighting or heating applications together with the reason why such wires are often coiled.

There will be three assessed activities in which the demonstration of knowledge and understanding will form a basic element of the assessment. The first activity will involve material testing and analysis of a simple static structure. Learners will be required to demonstrate an application of knowledge and understanding through investigation.

The second activity will involve the analysis of an electro-mechanical system which might contain pneumatic elements. Learners will be required to demonstrate an application of knowledge and understanding through an investigation of its function and operation.

The third activity will be concerned with the design and production of a simple instrumentation or control system. Learners will be required to produce a feasible design which takes full account of the operational requirements, production constraints and health and safety issues.

Links

Other units

This unit builds upon the knowledge gained in *Unit 1: Engineering, Materials, Processes and Techniques*. It also provides knowledge and understanding which supports and underpins the study of *Unit 6: Applied Design, Planning and Prototyping*.

Industry

Industrial practice is central to the delivery of this unit. The way in which pneumatic, hydraulic and electrical systems are used in real products are valuable contributions to the learners' understanding of these systems. The use of industrial contacts to provide visiting lectures, products of local engineering companies for learners to examine, and visits to see products in action are all valuable parts of the delivery of this unit.

Resources

Please note that while resources are checked at the time of publication, materials may be withdrawn form circulation and website locations may change.

Textbooks

There are no textbooks which cover the specific topics in this unit. However, the following may be useful.

Bird J — *Electrical and Electronic Principles and Technology* (Newnes, 2010) ISBN 0080890563

Morley A and Hughes E — *Principles of Electricity* (Longman, 1994) ISBN 0582228743

Tooley M and Dingle L — *Higher National Engineering* (Newnes, 2004) ISBN 0750661771

Websites

www.bbc.co.uk/schools/gcsebitesize/design	The British Broadcasting Corporation
www.deltacompsys.com/pdf/fluid%20power%20basics.pdf	
www.dtonline.org	Design and Technology Online
www.farnell.com	
www.howstuffworks.com/hydraulic.htm	
www.pneumaticsonline.com/basictraining/default.htm	Pneumatics Online Basic Training Course
www.rswww.com	
www.science.howstuffworks.com/light-bulb2.htm	
www.tlc-direct.co.uk/Technical/DataSheets/MK/Index.htm	

Unit 5: The Engineering Environment

Internally assessed

Introduction

In *Unit 2: The Role of the Engineer*, you investigated the role of the engineer and how the design and/or manufacture of an engineered product is influenced by different factors such as new technologies, legislation and standards.

In this unit you will investigate a different engineered product **or** service to the one studied in *Unit 2: The Role of the Engineer*, and you will extend your studies to learn how laws, regulations and codes of practice are used to ensure developments are safe. You will explore how procedures and paperwork systems are used to control engineering practice and product quality. You will also learn about different ways in which the environment is protected by the way products are designed and manufactured. You will explore how new techniques and scientific advances are used to improve the way products work, and how to create new products and services.

Recommended prior learning

Unit 1: Engineering Materials, Processes and Techniques

Unit 2: The Role of the Engineer

Unit 3: Principles of Design, Planning and Prototyping

What you need to learn

5.1 Legislation and documentation in engineering

There is a wide range of regulations, standards and documentation requirements that govern the way engineering products are designed, manufactured and maintained. You will investigate how specific engineering activities relevant to your engineered product or service are affected by these, which could include the following:

Regulations and standards

Regulations and standards define how a product should perform. These normally include safety standards, codes of practice, international and national standards and standards of performance.

For example, during your investigation, you may need to consider one or more of the following as appropriate to your product:

- electromagnetic compatibility
- radiation emissions
- energy efficiency
- waste disposal.

Documentation

There are many forms of documentation that are used during manufacturing and other engineering activities, and to support engineered products and services.

For example, during your investigation, you may need to consider one or more of the following as appropriate to your product:

- work procedures
- engineering drawings
- quality manuals
- repair manuals
- operating manuals
- product specifications.

5.2 The environmental impact of engineering activities

All engineering activities have an impact upon the environment. For example, during your investigation you may need to consider how your engineered product or service impacts on the environment, by considering some of the following, as appropriate to your product:

- energy efficiency
- design considerations
- pollution
- global warming
- renewable resources
- impact on local residents
- transport infrastructure.

5.3 The application of technology in engineering

The development of technological advances and the development of new materials and techniques have an impact upon the products and services that engineers create or modify. For example, during your investigation, you need to consider some of the following as appropriate to your engineered product or service:

- modern communications techniques (including data and satellite communications)
- computer networks
- new and smart materials
- electronic components
- optical materials.

5.4 Evaluation and modification

In this unit you will evaluate the engineered product or service you have investigated to assess its design and fitness for purpose.

You will make suggestions for modifications, where appropriate, that will improve the design or performance of the engineered product or service. Proposed modifications can be presented in the writing diagrams or as sketches/drawings.

Assessment evidence

Your portfolio should contain evidence of your work carried out in response to your investigation into **an** engineering product **or** service and the engineering activities that surround it. The engineered product **or** service should be a different product to that chosen in *Unit 2: The Role of the Engineer*.

Your work must include evidence of:

(a) standards and regulations that govern the engineered product **or** service, and their influence on the engineering activities

(b) the types of documentation used to support the engineered product **or** service during its development, manufacture and use

(c) how the requirement for energy efficiency is taken into consideration and its effect on the manufacture of the engineered product **or** service

(d) the environmental impact caused by the manufacture or maintenance of the engineered product **or** service

(e)* the technology and techniques used within the engineered product **or** service during its development, manufacture and maintenance

(f) an evaluation of the engineered product **or** service, and suggestions for modifications to improve its design or performance.

* Opportunity for learners to be assessed on Quality of Written Communication (QWC) — (i-iii).

Assessment criteria

	Mark band 1		Mark band 2	Mark band 3	Mark awarded
(a) **(AO1)**	• Provides a list of some general standards and regulations but which are not fully relevant to the engineered product or service. States how these affect the product and the engineering activities. **(0–2)**	• Provides a list of some general standards and regulations relevant to the engineered product or service. General explanation of how these affect the product and the engineering activities. **(3–4)**	• Identifies and describes some standards and regulations that are specifically relevant to engineered product or service. Provides some explanation of how these standards and regulations influence the product and the engineering activities. **(5–6)**	• Identifies and describes some relevant standards and regulations used with reasons for these being in place. Explains with justifications how the regulations and standards impact on the engineered product or service and the engineering activities. **(7–8)**	**8**
(b) **(AO2)** **(AO3)**	• Provides a list of some documentation and records employed in the development, manufacture and use, but they are not fully relevant to the engineered product or service. **(0–2)**	• Provides a list of some documentation and records employed in the development, manufacture and use, that are broadly relevant to the engineered product or service. **(3–4)**	• Identifies and describes the purpose and use of some documentation and records employed in the development, manufacture and use, that are specifically relevant to engineered product or service. **(5–6)**	• Identifies, describes and justifies the purpose and use of some documentation and records employed in the development, manufacture and use of the engineered product or service. **(7–8)**	**8**

	Mark band 1		Mark band 2	Mark band 3	Mark awarded
(c) **(AO2)** **(AO3)**	• Identifies one relevant energy efficiency issue and states how this has affected the manufacture of the engineered product or service. **(0-3)**	• Identifies some general energy efficiency issues that are relevant to the engineered product or service and briefly outlines the way in which the manufacture of the product has been affected by these issues. **(4-6)**	• Identifies and describes some specific energy efficiency issues that are relevant to the engineered product or service and explains the way in which the manufacture of the product has been affected by each of these issues. **(7-9)**	• Identifies and provides a clear explanation of key energy efficiency issues relevant to the engineered product or service. Explains how these have impacted on the manufacture of the product. Justifies the energy efficiency measure taken. **(10-12)**	**12**
(d) **(AO2)** **(AO3)**	• Identifies an environmental impact that has arisen from the manufacture or maintenance of the engineered product or service. **(0-2)**	• Identifies some relevant environmental impacts that have arisen from the manufacture or maintenance of the engineered product or service. **(3-4)**	• Identifies and explains some relevant environmental impacts that have arisen from the manufacture or maintenance of the engineered product or service. **(5-6)**	• Identifies and clearly explains the key relevant environment impacts that have arisen from manufacture and maintenance of the engineered product or service. **(7-8)**	**8**

	Mark band 1		Mark band 2	Mark band 3	Mark awarded
(e) **(AO2)**	• Identifies technologies **or** techniques used in the design, manufacture and maintenance of the engineered product or service.	• Identifies specific technologies **and** techniques used in the design, manufacture and maintenance of the engineered product or service.	• Identifies and explains why some specific technologies **and** techniques are essential to the successful design, manufacture and maintenance of the engineered product or service.	• Identifies, explains and justifies the significance and benefits of each specific technology **and** techniques used in the design, manufacture and maintenance of the engineered product or service.	
(AO3) **QWC (i-iii)**	• Uses everyday language and the response lacks clarity and organisation. Spelling, punctuation and the rules of grammar are used with limited accuracy.	• Uses everyday language but there are occasional uses of specialist vocabulary. The response lacks clarity and organisation although some attempt at focus is evident. Spelling, punctuation and the rules of grammar are used with occasional accuracy.	• Uses some specialist terms and the response shows some focus and organisation. Spelling, punctuation and the rules of grammar are used with some accuracy.	• Uses appropriate specialist terms consistently and the response shows good focus and organisation. Spelling, punctuation and the rules of grammar are used with considerable accuracy.	
	(0-3)	**(4-6)**	**(7-9)**	**(10-12)**	**12**

	Mark band 1		Mark band 2	Mark band 3	Mark awarded
(f) **(AO3)**	• Suggestions for modifications are superficial and cosmetic and will not offer any improvement in the intended design or performance of the engineered product or service. **(0-3)**	• Suggestions for modifications are simplistic and lacking in detail, and are unlikely to improve the design or performance of the engineered product or service. The suggestions simply reflect the evaluation comments. **(4-6)**	• Suggestions for modifications are offered, each originating from a different statement of evaluation and containing sufficient detail to show how it could improve the design or performance of the engineered product or service. **(7-9)**	• Well reasoned suggestions for modifications are given, each originating from a relevant statement of evaluation. Suggestions are supported by justifications and contain the details necessary to clearly show how each suggestion will improve the design or performance of the engineered product or service. **(10-12)**	**12**
				Total marks	**60**

(For description of AOs see *Performance descriptions* in *Appendix B*.)

Assessment guidance

When marking learners' work, you need to award individual marks for each assessment criteria. Using the Assessment criteria grid on pages 62-65, determine for each criterion the mark band in which the learners work comfortably sits. For mark band 1 we have subdivided the range to allow for an easier decision. A learner should be awarded the lower range of a particular mark range if they partially meet the statement. The upper range from that mark band should be awarded for the learner who is clearly within that statement and does not meet any of the statement from the above mark band. If you feel that the learner's work is actually fulfilling the next higher mark band range, then you need to repeat this process until you are happy you have decided on the correct mark band and the actual mark to be awarded.

For further guidance please refer to page 90 *Grading information*.

You should record your individual marks for each criteria for each learner using the Unit 5 Mark Record Sheet in the Edexcel GCE in the Engineering Teachers' Guide.

When submitting work for moderation, you must make sure that the mark record sheet is accompanied with the learner's work including witness statements where appropriate.

Delivering this unit

General

The knowledge and understanding required by this unit is linked to industrial practice. It is, therefore, essential that learning activities are linked to industry and are informed by industrial practice.

The preferred method of delivering this unit involves visits to engineering premises, product investigations and the use of case study material.

When considering the engineered product or service to be investigated, careful consideration should be given to the requirements of the assessment criteria/criterion in order to ensure that it is possible for learners to achieve the full mark range.

Industrial visits

Well-planned visits to industrial premises to observe products being designed, manufactured, and maintained will enable learners to understand the context in which engineering activities take place.

These will also provide opportunities to explore the way in which regulations, documentation, environmental issues, and energy efficiency affect engineering activities.

The visits will also provide opportunities to collect real documents, examine real issues and to gather relevant information that can be explored further in the classroom.

Learners should be assisted in formulating questions that will add to their knowledge before they carry out the visit. It is important that learners know what questions to ask beforehand. They should also be briefed on the projected visit to enable them to look out for key issues and information-gathering opportunities before the visit.

Access to people in industry via email questions and answers would also form a valuable resource for learners. This could be developed into a data bank for use in the future.

Product investigations

Product investigations can form an important part of the delivery of this unit. It is important that the product is supported by a range of associated support materials which could include real documents used in its manufacture and interviews with employees who are involved in designing, manufacturing and maintaining the product. Support materials could include video clips showing relevant aspects of the processes associated with the product. They could also include data on energy consumption and costs. Extracts from relevant regulations would also be helpful.

Case studies

Case studies showing the product design manufacture and maintenance could also form a valuable resource which could largely replace actual visits if necessary.

However, such case studies will need to be complex and extensive if they are to be useful in the delivery of this unit. They may typically consist of written information, video interviews with employees, promotional material, written procedures, engineering drawings, examples of products, manuals, numerical data and diagrams.

Links

Other units

There are links to *Unit 4: Applied Engineering Systems*. Both units can be studied at the same time.

This unit builds on *Unit 2: The Role of the Engineer*.

Industry

This unit is about industrial practice and, as such, requires the support of industry for its successful delivery. Examples of documents and procedures from industry will be a valuable resource in delivering this unit.

Resources

Please note that while resources are checked at the time of publication, materials may be withdrawn from circulation and website locations may change.

Textbooks

There are no textbooks which cover the specific content of this unit but the following may be useful.

Curtis A — *Business and Marketing for Engineers and Scientists* (McGraw-Hill, 1994) ISBN 0077078683

Hunt J E — *Business and Commercial Aspects of Engineering* (Butterworth-Heinemann, 1997) ISBN 0340676671

Tooley M and Dingle L — *Higher National Engineering* (Newnes, 2004) ISBN 0750661771

Websites

www.bsigroup.com	The British Standards Institution
www.etcni.org.uk	Engineering Training Council
www.environment-agency.gov.uk	The Environment Agency
www.semta.org.uk	Sector Skills Council for Science, Engineering and Manufacturing Technologies
www.theiet.org	The Institution of Engineering and Technology

Videos

Relevant video materials can be obtained from:

American Technical Publishers Ltd, 27-29 Knowl Piece, Wilbury Way
Hitchin, Hertfordshire, SG4 0SX
Web: www.atplearning.com
Telephone: 01462 437 933

BBC Videos for Education and Training
Web: www.bbcactive.com
Telephone: 0845 313 9999

Classroom Video
Web: www.classroomvideo.co.uk
Telephone: 0117 929 1924

TV Choice Ltd
Web: www.tvchoice.uk.com
Telephone: 020 8464 7402

Unit 6: Applied Design, Planning and Prototyping

Internally assessed

Introduction

This unit will draw upon the expertise you have gained during your studies of engineering.

You will design, develop and manufacture a solution to a client brief that will be given to you.

You will:

- carry out appropriate research into the requirements of the given client brief
- develop a technical design specification, negotiated and agreed with your client, that contains measurable points
- generate alternative design ideas and their development into a final design solution
- discuss your design solutions with other engineers (peer group) to evaluate progress and make modifications if necessary
- plan for production, identify tasks, time constraints, quality control points, and budgetary constraints
- consider, record and explain the use of appropriate regulations, standards and documentation during the manufacture of the engineered product
- produce a prototype of the engineered product that fully meets the specification requirements
- evaluate your final outcome against all the measurable points of the specification and suggestion modifications to improve the performance of the product.

Recommended prior learning

Unit 1: Engineering Materials, Processes and Techniques

Unit 2: The Role of the Engineer

Unit 3: Principles of Design, Planning and Prototyping

It is recommended that this unit is studied in parallel with:

Unit 4: Applied Engineering Systems

Unit 5: The Engineering Environment

What you need to learn

6.1 Research

Based on the client brief given to you, you will need to collect and record information that will assist you in developing a realistic technical specification.

You will need to carry out market research to establish the design details preferred by your target market.

You will need to analyse existing products to determine, for example, how they function, how they are constructed, what materials and processes have been used in their manufacture and how much they cost.

6.2 Technical specification

You will need to develop a technical design specification, containing key points identified from the research you carried out.

Your specification should be as comprehensive as possible and should contain measurable points against which your ideas and your prototype can be evaluated.

You should develop your specification in consultation with your client and it should contain information on:

- function of the product
- user requirements
- performance requirements
- material and component requirements
- quality and safety issues
- scale of production and cost.

6.3 Generation of alternative ideas and their development

Alternative design solutions

From your technical design specification you will produce at least **three** alternative design solutions that offer different proposals for solutions to the product requirements. Each different design solution should be realistic and match the points of the specification. You should include accompanying notes that review and evaluate each design solution for its fitness for purpose.

You should consider the following when producing your solutions:

- the selection of appropriate materials from the information gathered in your research
- how you will manufacture the product with the facilities available to you, but you also need to consider how it would be manufactured on a larger scale
- ergonomics — safety, effectiveness and comfort for use. You need to consider regulations, codes of practice and standards that would apply to your initial ideas.

Final design solution

Your final design solution should bring together the most suitable sub-systems or part designs taken from your initial design ideas and develop them into a workable solution that fully matches the specification using current industry standards and conventions.

Development must show change and how the initial ideas have moved on in response to feedback and evaluation.

Modelling and testing using computer software and/or hardware should take place during your development.

Where numerical values are included as part of the proposed solution, you should show how you applied your scientific and mathematical understanding to arrive at your outcome. Where materials are selected for use because of their scientific properties, you should show any relevant scientific and mathematical data you used in selecting the material.

6.4 Formative evaluation

At the design and development stage of your project, your progress should be reviewed and evaluated by a team of engineers who will offer objective feedback on how the design solution matches the specification and whether the intended design is likely to succeed.

You will use this formative, objective evaluation to inform future decisions regarding further development of the design solution.

The term 'engineers' can be interpreted as members of a peer group who are engaged in the same activities and who have a similar level and range of expertise.

6.5 Planning for production

You will need to produce a plan for production that considers all the manufacturing processes that would be involved in the manufacture of your product on a commercial scale.

You must include proposed timings for particular tasks as well as points at which quality control checks need to be carried out. You should provide a full explanation of the quality control checks.

Your planning must include proposed costing for the manufacture of the product.

Your plan for production should include a record and explanation of the appropriate regulations, standards and documentation that need to be considered in order to achieve a successful outcome.

A plan for production is a forward-looking document and not a retrospective diary of events and it only considers the manufacture of the product.

6.6 Prototype production

You will produce a working prototype that fully matches your final design solution.

A prototype is a first attempt at a representative-working product. Its primary function is to prove the design principles and to demonstrate how the product will look and function.

In your prototype production, you should demonstrate a clear understanding of why you have selected particular materials, components and processes referring to any scientific and/or mathematical principles you used.

You should ensure that your final outcome relates fully to all of the features you have specified in your design solution, for example material, construction, finish.

During manufacture, you should demonstrate high level manufacturing skills that show precision and attention to detail.

You should demonstrate a high level of safety awareness when working with machinery, tools and equipment.

6.7 Final evaluation

When you have completed your prototype, you must test and evaluate its performance against what you set out to achieve in your specification.

You should devise appropriate tests for each of the measurable points of the specification and check that your prototype matches the quality of performance specified.

These tests should be done under real working conditions and ideally will include potential users, who should comment on their findings.

Your test results, and those of the user group, can be used to evaluate your prototype objectively against the specification.

As a result of testing and evaluation ideas for possible modifications will arise and these should be included in this section in sufficient detail to explain how their use will improve the design and performance of your product in the future.

Assessment evidence

Your portfolio should contain evidence of your work carried out in the design, development and manufacture of an engineered product.

You will submit your work on A4 paper apart from the engineering drawings that will be submitted on A3 paper. You will also include photographic evidence of your final prototype.

Relevant health and safety issues should be addressed throughout your portfolio.

Your work must include evidence of:

(a) appropriate research and the development of a technical specification

(b) generation of at least **three** alternative design ideas and their development into a final design solution using appropriate current industry standards and conventions

(c) reviewing feedback gathered from other engineer(s) (your peer group) on your initial design solutions

(d) planning for production

(e) prototype manufacture

(f)* testing, evaluation and suggestions for modifications to improve the performance of the engineered product.

* Opportunity for learners to be assessed on Quality of Written Communication (QWC) — (i-iii).

Assessment criteria

	Mark band 1		Mark band 2	Mark band 3	Mark awarded
(a) **(AO1)** **(A02)**	• Gather information from a single, general information source. • The specification is limited and superficial, containing simple statements and no measurable points. **(0–2)**	• Gather information from a limited number of sources specific to the product. • The specification is developed from some points identified in the research but does not contain measurable points. **(3–4)**	• Use a range of relevant sources to gather technical information, including scientific and/or mathematical data, where appropriate, that can be used to inform future design decisions. • The specification uses research material and focuses on most key points from the research. Most points are measurable and explained and can be measured and evaluated against the final prototype. **(5–6)**	• Select detailed technical information from a wide range of appropriate sources, including justified scientific and/or mathematical data, where appropriate, that can be used to inform future design decisions. • The specification is detailed and reflects the technical aspects of the research material. Main key points are considered and justified and can be measured and evaluated against the final prototype. **(7–8)**	**8**

	Mark band 1		Mark band 2	Mark band 3	Mark awarded
(b) (AO1) (AO2) (AO3)	• Presentation of some alternative design solutions, using appropriate current industry standards and conventions, that are realistic but similar to each other. Ideas address a limited number of specification points but are superficial. • Developments are cosmetic and minor. No consideration is given to commercial manufacturing of the product. **(0–4)**	• Presentation of some alternative design solutions, using appropriate current industry standards and conventions, that are realistic and different. Ideas will take into account research and information gathered and address some specification points. • Developments are limited but appropriate and show how the product has been improved by the inclusion of some features of the alternative ideas. Some modelling is presented in the form of 2D or 3D to test an aspect of the developed design. Limited aspects of commercial manufacturing requirements for the product are considered. **(5–8)**	• Presentation of a range of alternative design solutions, using appropriate current industry standards and conventions, that consider different approaches, identifies subsystems and some scientific and/or mathematical principles, where appropriate, to determine values. Ideas are influenced by research and information gathered and will address most technical specification points. • Uses some details of sub-systems and/or part-ideas from previously considered alternative design solutions to help develop and refine a final workable design solution. Models and tests some aspects of the final design solution against some technical aspects of the specification. Considers some commercial manufacturing requirements for the product. **(9–12)**	• Presentation of a range of alternative design solutions, using appropriate current industry standards and conventions, that reflect a broad and detailed understanding of the requirements of the product that focus fully on the specification points. Alternative ideas are realistic, workable and detailed and will include justification through scientific and/or mathematical information of most technical performance values. Ideas will demonstrate a good understanding of appropriate materials, processes and technologies specified for use in the product design. • Develops, tests and refines a final design solution that considers and uses sub-systems and/or part-designs from previously considered alternative ideas to help produce a final workable design solution that meets most technical aspects of the specification. The developed solution will be significantly different or improved compared to any previous alternative designs and will show how the design has been 'moved on'. Development will include consideration of the commercial manufacturing requirements for the product. **(13–16)**	**16**

	Mark band 1		Mark band 2	Mark band 3	Mark awarded
(c) (AO3)	• Evidence of a general review with other engineer(s)/peer(s) with little organisation. Limited useful technical feedback that could be used constructively in future developments of the product. **(0–2)**		• Evidence of a review with other engineer(s)/peer(s) that shows some planning and organisation. Technical feedback is focused on some aspects of the specification, ideas and development and has some use in future developments of the product. **(3–4)**	• A record of a well-organised, detailed review with other engineer(s)/peer(s) that focuses succinctly on specific technical points of specification, design and development. The review content is technically accurate, logical and precise. A clear understanding of how feedback will be used in future developments of the product. **(5–6)**	**6**
(d) (AO2)	• A plan for production that contains some reference to unrealistic deadlines. Some reference to tasks and procedures identified. Quality control points, costs and scale of production are not taken into account.	• A plan for production with some deadlines. Tasks and procedures identified. Quality control points, costs and scale of production are identified.	• A plan for production with realistic deadlines. Most tasks and processes explained. Quality control checks, costs and scale of production are taken into account and explained.	• A plan for production that shows a logical sequence of events and a good understanding of the processes and resources appropriate to the scale of production. Deadlines are achievable and time is managed effectively. The plan considers tasks, time and quality control and explains budgetary constraints.	
	• Identification of a limited number of regulations, standards and documentation used in manufacturing, without reference to the specified product. **(0–2)**	• Identify some regulations, standards and documentation that are used in manufacturing with some relevance to the specified product. **(3–4)**	• Some regulations, standards and documentation relevant to the specified product are identified and their role in its manufacture is explained. **(5–6)**	• Most regulations, standards and documentation relevant to the identified product are explained and justified in their use in product manufacture. **(7–8)**	**8**

	Mark band 1		Mark band 2	Mark band 3	Mark awarded
(e) **(AO3)**	• A limited understanding of a range of materials, components and processes is used to manufacture a prototype that broadly matches some aspects of the final design solution. Manufacturing skills are limited and show poor attention to detail. The prototype hardly functions as intended. There is little evidence that scientific and/or mathematical information has been used in selecting materials, components and processes. Some general safety awareness is displayed. **(0–4)**	• An appropriate understanding of a limited range of materials, components and processes is used in the manufacture of a prototype that functions adequately and matches some aspects of the final design solution. Manufacturing skills show some attention to detail and the choice of the selection of appropriate materials, components and processes is supported by some use of scientific and/or mathematical information. Some relevant awareness of safe working conditions is displayed. **(5–8)**	• A good understanding of an appropriate range of materials, components and processes are used to produce a prototype that functions well and matches most technical aspects of the final design solution. Good quality manufacturing skills that demonstrate attention to detail are used in conjunction with materials, components and processes, most of which have been selected using scientific and/or mathematical information, to produce a good quality product. Awareness of safe working practices for most specific processes is demonstrated. **(9–12)**	• A detailed understanding of a wide and appropriate range of materials, components and processes has been used to produce a high quality prototype that is fully functional and matches all aspects of the final design solution. High level making skills that demonstrate precision are in evidence and the selection of materials, components and processes used in manufacture are justified through the application of appropriate scientific and/or mathematical information. High levels of awareness of safe working practices for all relevant processes are in evidence. **(13–16)**	**16**

	Mark band 1	Mark band 2	Mark band 3	Mark awarded
(f) **(AO3)** **QWC (i-iii)**	• No relevant testing is carried out. Evaluation is superficial and subjective. Modifications are cosmetic and have no potential to improve the performance or quality of the product. • Uses everyday language and the response lacks clarity and organisation. Spelling, punctuation and the rules of grammar are used with limited accuracy. **(0–2)**	• Some tests are carried out against points of the specification. Some points of evaluation are objective and relate to the specification. Modifications arise from tests and evaluated points and are designed to improve the performance or quality of the product. • Uses some specialist terms and the response shows some focus and organisation. Spelling, punctuation and the rules of grammar are used with some accuracy. **(3–4)**	• Tests carried out are explained and justified. Detailed evaluation is objective and set against most measurable points of the specification. The views of a client or potential users are considered. Modifications are explained and justified to show how they will improve the performance or quality of the product. • Uses appropriate specialist terms consistently and the response shows good focus and organisation. Spelling, punctuation and the rules of grammar are used with considerable accuracy. **(5–6)**	**6**
			Total marks	**60**

(For description of AOs see *Performance descriptions* in *Appendix B*.)

Assessment guidance

When marking learners' work, you need to award individual marks for each assessment criteria. Using the *Assessment criteria* grid on pages 74-78, determine for each criterion the mark band in which the learners work comfortably sits. For some of the assessment criteria in mark band 1 we have subdivided the range to allow for an easier decision. A learner should be awarded the lower range of a particular mark range if they partially meet the statement. The upper range from that mark band should be awarded for the learner who is clearly within that statement and does not meet any of the statement from the above mark band. If you feel that the learner's work is actually fulfilling the next higher mark band range, then you need to repeat this process until you are happy you have decided on the correct mark band and the actual mark to be awarded.

For further guidance please refer to page 90 *Grading information*.

You should record your individual marks for each criteria for each learner using the Unit 6 Mark Record Sheet in the Edexcel GCE in the Engineering Teachers' Guide.

When submitting work for moderation, you must make sure that the mark record sheet is accompanied with the learner's work including witness statements where appropriate.

Delivering this unit

General

The delivery of this unit will require careful planning to ensure that the subject matter is delivered in an interesting and stimulating way.

Contact with industry is critical to the successful and effective delivery of this unit.

In considering the product that will be designed and manufactured, careful consideration should be given to the requirements of the assessment criteria/criterion in order to ensure that it is possible for learners to achieve the full mark range.

Client brief

You should generate the client brief for the learner or it can be generated by another source identified by the learner as a starting point.

The client brief must be a clear description of the problem the learner will solve.

The brief will include the recognition of a problem, identification of needs and enough information to place the problem into context. The information included in the brief will be simple, focused and concise, giving direction to the learner. However it will not be so precise as to leave no room for development of their ideas by imposing unnecessary constraints on any proposed design solutions they may produce.

The client brief **must** be significantly different to the one given in *Unit 3: Principles of Design, Planning and Prototyping*.

Design process

Learners should be encouraged to discuss the brief with a client or their peers to establish and confirm the key features and to refine the needs of the brief. The client brief should take into account the centre's resources in that the engineering product needs to be manufactured.

Project planning and management

Learners should aim to build on the skills gained in *Unit 3: Principles of Design, Planning and Prototyping* and should plan in detail a route through their project. It is important to build into the plan opportunities to meet with clients and other engineers to gain feedback on progress made.

Possible visits to commercial manufacturing companies to see how planning is done in the real world will be of benefit.

Engineered product

Definition

In this context the term 'engineered product' may be interpreted to include:

- a physical product, for example an item of mechanical, electronic, fluidic equipment
- a service product, for example, a dial-up data or voice communications service
- a 'system' product, for example, a specialised computer database or software application.

Selecting a project

Learners are required to undertake a project leading to the manufacture of an engineered product, based on a detailed client brief.

In selecting a suitable project the following points should be borne in mind:

- The starting point for a project should be the client brief, based on which the learners must design and develop an appropriate solution (the 'product'). Learners should not start from the premise that they wish to produce a particular product.
- The project should provide an opportunity for learners to address the full range of requirements stated in the assessment criteria, and therefore to have access to the full range of available marks.
- Beyond this, the project should not be over-ambitious or over-demanding for the learner or centre in terms of the knowledge, skills, resources or time made available for delivering the unit.
- In practice, projects leading to 'service' products are likely to be more challenging to learners and centres, because of difficulties in the research and product implementation ('manufacturing') phases of the project.
- Consideration should be given to the interests, motivation and abilities of individual learners.
- Experience suggests that the best projects are those that arise out of a real requirement, possibly one identified by a customer, or through an industrial or commercial contact.

Producing an engineered product

Learners should have access to appropriate workshop facilities to manufacture the engineering product or service described in the client brief.

During the course of design, developing and manufacture of the prototype, learners should, where appropriate, be encouraged to support and justify their decisions through the use of scientific and mathematical information.

Witness statements and photographic evidence should be used to provide evidence of safe, correct and competent use of appropriate tools, equipment, techniques and processes.

Casing

It is important to strike a balance between the amount of effort applied to the 'technology' content of a project and the effort directed to the use of materials to produce a case in which to hold electronic circuitry or a mechanical system. It is not appropriate to allow learners to spend the majority of their time on designing, developing and manufacturing a high quality case and then using a 'found' circuit or system that is not understood or personalised in any way.

Engineering work should be dominated by the knowledge and understanding related to the technology involved and evidence of this should be present throughout the portfolio. Design and development of the casing should be of secondary importance. As a general guide, learners should divide their efforts in a ratio of about 70:30 in favour of the technological content of their work. A learner, who presents high quality designing and manufacturing skills for the case and simplistic, low-level 'technology' work, will not score in the high categories of assessment. However, a learner who produces a complex and successful solution to a challenging technological problem, but manufactures a simple, poorly finished undemanding case can still achieve marks in the higher categories of assessment.

Mechanisms project work will, by its nature, require more use of materials to construct structures in which to house mechanical systems, but the portfolio must reflect the focus on technological content described previously.

Photographic evidence

It is essential that high quality photographic evidence is presented in support of learners' work, but it is not acceptable to simply photograph the external casing of a product without adding important details to accompany this general view.

Where electronic circuitry is included in a project, photographs must show a learner's skills in electronic manufacturing. This should include details of quality of soldering, how flying leads are dealt with, how exposed wires and switch contacts are insulated, how batteries are secured and accessed and how circuit boards are anchored.

Close-up details of mechanical systems should be similarly photographed to support the levels of assessment awarded by centres.

Links

Other units

This unit builds on the skills learnt in *Unit 3: Principles of Design, Planning and Prototyping*, and should also build on the knowledge and understanding gained while studying the other units across the AS and A2 award. Knowledge of materials, processes and engineering systems, procedures, regulations and environmental issues should be incorporated into the overall project.

Industry

Visits to engineering design companies will help focus learners' ideas on projects and project management.

Resources

Please note that while resources are checked at the time of publication, materials may be withdrawn from circulation and website locations may change.

Textbooks

There are no textbooks which cover the specific content of this unit but the following may be useful.

Baguley P — *Teach yourself Project Management* (Teach Yourself, 2003) ISBN 0340867302

Lester A — *Project Planning and Control* (Butterworth-Heinemann, 2005) ISBN 0750658436

Lock D — *Project Management, 9th Edition* (Gower Publishing, 2007) ISBN 0566087723

McFarlane B — *Beginning AutoCAD 2002* (Butterworth-Heinemann, 2002) ISBN 0750656107

Reiss G — *Project Management Demystified* (Routledge, 2007) ISBN 0415421632

Simmons and Maguire — *Manual of Engineering Drawing* (Butterworth-Heinemann, 2003) ISBN 0750651202

Smith N J — *Engineering Project Management* (Blackwell, 2002) ISBN 0632057378

Websites

www.bsi.co.uk	The British Standards Institution
www.semta.co.uk	Sector Skills Council for Science, Engineering and Manufacturing Technologies

Assessment information

Assessment Objectives (AO) and weightings

There are three Assessment Objectives for GCEs in Engineering. They detail the knowledge, skills and understanding that learners are required to demonstrate.

For this qualification, the weightings for each Assessment Objective are given below.

Assessment Objectives		Weighting		
		AS	**A2**	**Advanced Subsidiary GCE and Advanced GCE**
AO1	**Knowledge and understanding** Candidates recall and apply knowledge, skills and understanding from across the specification content in a range of engineering situations.	20–30%	20–30%	20–30%
AO2	**Application of knowledge and understanding through investigation** Candidates plan and carry out investigations and tasks in which they analyse engineering issues and problems and gather, record and analyse relevant information, data and other forms of evidence in the areas of study identified in the specification content in a range of engineering situations.	30–40%	30–40%	30–40%
AO3	**Design and production** Candidates integrate knowledge, skills and understanding to independently analyse an engineering situation or problem; design, produce and communicate a response and evaluate outcomes and approach, making contributions to teamwork.	40–50%	40–50%	40–50%

Relationship of Assessment Objectives to units

Unit	AO1	AO2	AO3
1	70%–80%	10%–20%	10%-20%
2	0%	70%	30%
3	10%	10%	80%
4	30%	30%	40%
5	15%	40%	45%
6	15%	20%	65%

External assessment

Unit 1: Engineering Materials, Processes and Techniques

- This unit will be assessed through an examination set and marked by Edexcel.
- There will be a 1 hour and 30 minute examination paper.
- The examination will be available in each June examination series.
- The paper will be a question and answer booklet.
- Each examination paper will have one or more themes. Each theme will be a common engineered product. The product(s) will provide opportunities to ask questions about the choice and application of particular materials, joining techniques and processing methods in the context of a specific application. Actual knowledge of the product(s) will not be required in order to answer the questions in the examination. The product(s) will merely give a context in which learners can demonstrate their subject knowledge and understanding.

Unit 4: Applied Engineering Systems

- This unit is externally assessed and will be based on a brief set by Edexcel each year. The brief, containing **three** practical activities, will be similar each year but the topic/product selected will vary. The examination will be available in each June examination series.
- The brief will **only** be available from the Edexcel website (www.edexcel.com). This will be available from September for each year and will be moderated by Edexcel in the following summer.
- Working under controlled/managed conditions, learners will work independently to complete all three practical activities to fulfil the requirements of this unit.
- Learners should spend no more than 10 hours in completing all three practical activities.
- A deadline date for submitting marks and sample work to Edexcel will be set and issued with the brief.
- Although this is an externally set and assessed unit, centres will be required to internally assess the learners' work using the set assessment criteria. Edexcel will moderate a sample of centres' marking. Centres should note that Edexcel moderates this unit only in the June examination series.

Internal assessment

Supervision of learners and authentication of work submitted

Learners must submit a portfolio of work for each internally assessed unit. Teachers are expected to guide and advise learners on the production of their portfolios. Teachers should monitor progress to ensure that the work is appropriate for the requirements of the specification. The GCSE, GCE, and GNVQ Code of Practice requires that assessors record full details of the nature of any assistance given to individual learners beyond that of the teaching group as a whole, but within the parameters laid down in this specification. The level of assistance should be taken into account when assessing learners' work; this is indicated in the *Delivering this unit* section that accompanies each internally assessed unit in this specification. In addition, sufficient work must take place under direct supervision to allow the teacher marking the work to authenticate each learner's work with confidence.

If learners' practical skills are being assessed it is important that witness statements/checklists are completed by assessors to authenticate learner work and provide evidence that learners have achieved the level of performance required in the assessment criteria grid.

Witness Statements can be found in *Appendix C*.

Applying the mark bands

Portfolios will be marked by the centre, and externally moderated by Edexcel. Each of the internally assessed units has an assessment criteria grid, divided into three broad mark bands, showing how to award marks in relation to the task and the Assessment Objectives. The assessment criteria grids indicate the required assessment outcomes as well as the quality of the outcomes needed for achievement in each of the mark bands. In general terms, progression across the bands is characterised as follows.

- The assessment criteria grid shows the allocation of marks by assessment criterion and by mark band. This grid should be used to determine marks for learner achievement in each unit. Learners can achieve marks in different bands for each assessment objective. The total mark achieved will depend on the extent to which the learner has met the assessment criteria overall.
- Within each assessment criterion, it is a general principle that shortcomings in some aspects of the assessment requirements may be balanced by better performance in others. However, it is also important to note that for full marks in any particular assessment criterion, all the requirements should have been met.
- Marks should be awarded according to the criteria for each strand set out in the assessment criteria grid, and assessors should apply their professional judgement where relevant. The *Assessment guidance* section in each unit gives specific details of how marks should be allocated.
- There should be no reluctance to use the full mark range and, if warranted, assessors should award maximum marks. Learners' responses should be considered positively. A mark of 0 should be awarded only where the learner's work does not meet any of the required criteria.

- All learners are entitled to initial guidance in planning their work, but the level of assistance required should be taken into account when their work is assessed. In this publication, reference may be made to learners working with 'some support and guidance', with 'limited guidance' and 'independently'. When marking the work, assessors should follow the guidelines below.
  - '*Some support and guidance*': the learner has to be guided and advised throughout to ensure that progress is made. The learner relies on the support of the teacher, who has to assist in most aspects of the work. This level of support restricts the learner's mark to band 1, irrespective of the quality of the outcomes
  - '*Limited guidance*': the teacher supports the learner in the choice of topic for investigation. From then on, the teacher reacts to questions from the learner and suggests a range of ideas that the learner acts on. The learner frequently checks matters of detail. The teacher needs to assist in some aspects of the work. This level of support restricts the learner's mark to bands 1 or 2, irrespective of the quality of the outcomes
  - '*Independently*': the teacher supports the learner in the choice of topic for the investigation or task. From then on, the teacher occasionally helps the learner, and only when asked, but monitors progress throughout. This level of support gives access to all three mark bands.
- For internal record-keeping purposes, centres may wish to make a copy of the assessment criteria grid for each learner and use it to record the mark for that unit. The GCSE, GCE, GNVQ Code of Practice requires assessors to show clearly how credit has been assigned.

Differentiation across AS and A2 units

Differentiation across AS and A2 units is characterised in general terms by:

- increasing depth and breath of understanding
- increasing application of knowledge and understanding and skills
- increasing analysis, synthesis and evaluation
- increasing independence.

There is also differentiation through the content of the units. AS unit content forms the foundation of knowledge and understanding which underpins the higher-level concepts found in the A2 units.

Synoptic assessment

Synoptic assessment occurs at A2 in *Unit 6: Applied Design, Planning and Prototyping*. It is designed to link together, concepts, skills, knowledge and understanding across the entire course. The synoptic unit is internally assessed as a project, where learners apply their knowledge of materials, engineering processes, regulations and codes of practice, as well as their scientific and mathematical principles to solve an engineering problem.

Standardisation and moderation

Where marking for a unit has been carried out by more than one assessor in a centre, there must be a process of internal standardisation to ensure that there is consistent application of the criteria laid down in the assessment criteria grids.

Marks awarded by the centre will be subject to external moderation by Edexcel. This is to ensure consistency with national standards. A sample of learner portfolios will be examined, and marks will be adjusted where they are found to vary from the national standard. If the moderation process reveals an inconsistent application of the assessment criteria by centre assessors. Edexcel reserves the right to return the sample work in order for internal standardisation to be carried out.

Language of assessment

Assessment for this qualification will be available in English only. Assessment materials will be published in English only and all written and spoken work submitted for examination and moderation must be produced in English.

Statutory requirements

All assessment of this qualification will be carried out in accordance with the GCSE, GCE and GNVQ Code of Practice, published annually by the regulatory authorities.

Grading information

Mark bands

The assessments are designed to allow learners to demonstrate positive achievement and to have a positive experience in completing each assessment.

In line with the above, the criteria for assessing each assignment have been written so that a learner working at the lower end of the GCE ability range should be capable of meeting approximately 80 per cent of the band 1 criteria. This equates to approximately 40 per cent of the total credit available for the assignment.

Grading, aggregation, and equivalence

The overall grade for:

- Advanced Subsidiary (Single Award) qualifications will be graded on a five-grade scale from A to E where A is the highest grade.
- Advanced GCE (Single Award) qualifications will be graded on a six-grade scale from A* to E where A* is the highest grade.

The mark bands used for internal assessment do not relate to pre-determined grade boundaries. Following each examination and moderation series, Edexcel will set the grade boundaries for internally and externally assessed units at an awarding meeting.

The raw mark boundaries will be converted to uniform marks on a scale of 0–100. The final grade for the qualification will be determined by aggregating the uniform marks for the units. The table below gives details of the uniform mark scales (UMS) used for the units and for the qualifications.

In Advanced, to gain Grade A* candidates must gain Grade A on the qualification overall and at least 90% of the maximum uniform mark on the aggregate of the three A2 units.

Unit results

The minimum uniform marks required for each grade:

Unit grade	**A**	**B**	**C**	**D**	**E**
Maximum uniform mark = 100	**80**	**70**	**60**	**50**	**40**

Candidates who do not achieve the standard required for a grade E will receive a uniform mark in the range 0–39.

Qualification results

Advanced Subsidiary (Single Award)

The minimum uniform marks required for each grade:

Qualification grade	A	B	C	D	E
Maximum uniform mark = 300	**240**	**210**	**180**	**150**	**120**

Candidates who do not achieve the standard required for a grade E will receive a uniform mark in the range 0–119.

Advanced GCE (Single Award)

The minimum uniform marks required for each grade:

Qualification grade	A	B	C	D	E
Maximum uniform mark = 600	**480**	**420**	**360**	**300**	**240**

Candidates who do not achieve the standard required for a grade E will receive a uniform mark in the range 0–239.

Performance descriptions

Performance descriptions are given in *Appendix B*.

Additional information

Learner entry

Details of how to enter learners for this qualification can be found in Edexcel's *Information Manual* produced each year, a copy is sent to all Examinations Officers. The information can also be found on our website (www.edexcel.com).

Resitting of units

There is no restriction on the number of times a unit may be attempted before claiming certification for the qualification. The best available result for each unit will count towards the final grade.

Results of units will be held in Edexcel's unit bank for as many years as this qualification remains available. Once the Advanced Subsidiary or Advanced GCE qualification has been certificated, all unit results are deemed to be used up at that level. These results cannot be used again towards a further award of the same qualification at the same level, but unit results used for an Advanced Subsidiary remain available for use in an Advanced GCE qualification.

Access arrangements and special requirements

Edexcel's policy on access arrangements and special considerations for GCE, GCSE, and Entry Level is designed to ensure equal access to qualifications for all students (in compliance with the Equality Act 2010) without compromising the assessment of skills, knowledge, understanding or competence.

Please see the Joint Council for Qualifications (JCQ) website (www.jcq.org.uk) for their policy on access arrangements, reasonable adjustments and special considerations.

Please see our website (www.edexcel.com) for:

- the forms to submit for requests for access arrangements and special considerations
- dates for submissions of the forms.

Requests for access arrangements and special considerations must be addressed to:

Special Requirements
Edexcel
One90 High Holborn
London WC1V 7BH

Equality Act 2010

Please see our website (www.edexcel.com) for information on the Equality Act 2010.

Quality of Written Communication (QWC)

Learners will be assessed on their ability to:

i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear

ii) select and use a form and style of writing appropriate to purpose and to complex subject matter

iii) organise information clearly and coherently, using specialist vocabulary when appropriate.

Stretch and challenge

Learners can be stretched and challenged in A2 units through the use of different assessment strategies, for example:

- using a variety of stems in questions — for example analyse, evaluate, discuss, compare
- ensuring connectivity between sections of questions
- a requirement for extended writing
- use of a wider range of question types to address different skills — for example open-ended questions, case studies etc.

Malpractice and plagiarism

For up-to-date advice on teacher involvement, malpractice and plagiarism, please refer to the latest *Joint Council for Qualifications (JCQ) Instructions for Conducting Coursework* document. This document is available on the JCQ website: www.jcq.org.uk.

For additional information on malpractice, please refer to the latest *Joint Council for Qualifications (JCQ) Suspected Malpractice in Examinations and Assessments: Policies and Procedures* document, available on the JCQ website.

Learner recruitment

Edexcel's access policy concerning recruitment to our qualifications is that:

- they must be available to anyone who is capable of reaching the required standard
- they must be free from barriers that restrict access and progression
- equal opportunities exist for all learners.

The wider curriculum

Spiritual, moral, ethical, social, cultural (SMESC) and other wider curriculum links

This qualification gives opportunities for developing an understanding of spiritual, moral, ethical, social and cultural issues, together with an awareness of environmental issues, health and safety considerations, and European initiatives consistent with relevant international agreements appropriate for the engineering sector. *Appendix A* maps the opportunities available.

Resources and support

Edexcel publications

You can order further copies of the Specification, Sample Assessment Materials (SAMs) and Teacher's Guide documents from:

Edexcel Publications
Adamsway
Mansfield
Nottinghamshire NG18 4FN

Telephone: 01623 467467
Fax: 01623 450481
Email: publication.orders@edexcel.com
Website: www.edexcel.com

Endorsed resources

Edexcel also endorses some additional materials written to support this qualification. Any resources bearing the Edexcel logo have been through a quality assurance process to ensure complete and accurate support for the specification. For up-to-date information about endorsed resources, please visit www.edexcel.com/endorsed.

Please note that while resources are checked at the time of publication, materials may be withdrawn from circulation and website locations may change.

Edexcel support services

ResultsPlus – ResultsPlus is an application launched by Edexcel to help subject teachers, senior management teams, and students by providing detailed analysis of examination performance. Reports that compare performance between subjects, classes, your centre and similar centres can be generated in 'one-click'. Skills maps that show performance according to the specification topic being tested are available for some subjects. For further information about which subjects will be analysed through ResultsPlus, and for information on how to access and use the service, please visit www.edexcel.com/resultsplus

Ask the Expert – to make it easier for our teachers to ask us subject specific questions we have provided the **Ask the Expert** Service. This easy-to-use web query form will allow you to ask any question about the delivery or teaching of Edexcel qualifications. You'll get a personal response, from one of our administrative or teaching experts, sent to the email address you provide. You can access this service at www.edexcel.com/ask

Support for Students

Learning flourishes when students take an active interest in their education; when they have all the information they need to make the right decisions about their futures. With the help of feedback from students and their teachers, we've developed a website for students that will help them:

- understand subject specifications
- access past papers and mark schemes
- learn about other students' experiences at university, on their travels and entering the workplace

We're committed to regularly updating and improving our online services for students. The most valuable service we can provide is helping schools and colleges unlock the potential of their learners. www.edexcel.com/students

Appendices

Appendix A: Wider curriculum

Signposting

Issue	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6
Moral		✓				
Ethical		✓				
Social		✓			✓	
Environmental					✓	
Health and safety	✓	✓	✓	✓	✓	✓
European initiatives		✓			✓	

Development suggestions

Issue	AS/A2 units	Opportunities for development
Moral	2	The role of engineers and the moral obligation to operate within codes of practice.
Ethical	2	The ethical issues involved in obeying regulations, codes of practice, and procedures are covered in this unit.
Social	2, 5	The social impact of engineering processes and working practices such as shift work.
Environmental	5	This unit covers the environmental impact of engineering activities.
Health and safety	1, 2, 3, 4, 5, 6	The units cover health and safety considerations when designing or manufacturing an engineered product.
European initiatives	2, 5	The introduction of Europe-wide regulation such as CE marking of products.

Appendix B: Performance descriptions

- The performance descriptions for GCE Engineering aim to describe learning outcomes and levels of attainment likely to be shown by a representative candidate performing at the A/B and E/U boundaries for the AS and A2. The performance descriptions illustrate the expectations at these boundaries for the AS and A2 as a whole; they have not been written at specification or unit level.
- Each performance description is aligned to one Assessment Objective. An alphabetical system has been used to denote each element of a performance description. There is no hierarchy of elements.
- Performance descriptions are designed to assist examiners in exercising their professional judgement at awarding meetings where the grade A/B and E/U boundaries will be set by examiners using professional judgement. This judgement will reflect the quality of the candidates' work, informed by the available technical and statistical evidence. Performance descriptions will be reviewed continually and updated where necessary.
- Teachers may find performance descriptions useful in understanding candidates' performance across qualifications as a whole but should use the marking criteria identified in the specification when assessing candidates' work.
- The requirement for all AS and Advanced GCE level specifications to assess learners' Quality of Written Communication will be met through all the Assessment Objectives in a range of work-related contexts.

The performance descriptions for AS indicate the level of attainment characteristic of A/B and E/U boundary learners. They give a general indicator of the required learning outcomes. The descriptions should be interpreted in relation to the content outlined in the specification; they are not designed to define the content. The grade awarded will depend in practice upon the extent to which the learner has met the Assessment Objectives overall. Shortcomings in some aspects of the examination may be balanced by better performance in others. The requirement for all AS and A2 specifications to assess learners' quality of written communication will be met through all the Assessment Objectives.

The difference between the AS and A2 standard is determined by:

- the greater challenge presented by the A2 subject content
- the demands of the synoptic assessment
- more challenging Assessment Objective weightings at A2
- the differences spelt out in the following performance descriptions.

AS	Assessment Objective 1	Assessment Objective 2	Assessment Objective 3	Quality of Written Communication
Assessment Objective	Learners recall and apply knowledge, skills and understanding from across the specification content in a range of engineering situations.	Learners plan and carry out investigations and tasks in which they analyse engineering issues and problems and gather, record and analyse relevant information, data and other forms of evidence in a range of engineering situations.	Learners integrate knowledge, skills and understanding to independently analyse an engineering situation or problem; design, produce and communicate a response and evaluate outcomes and approach, making contributions to teamwork.	
A/B boundary performance description	**Learners:** • recall and apply knowledge and understanding from all parts of the specification with few omissions • consistently demonstrate an understanding of the principles and concepts outlined in the specification, and apply these to familiar situations with minimal guidance • carry out calculations with some guidance usually obtaining the correct solutions with units.	**Learners:** • carry out investigations taking account of constraints, anticipating potential problems • make and record appropriate observations and use them to evaluate procedures, techniques and equipment • evaluate a range of information sources selecting the most appropriate • interpret trends and patterns in data.	**Learners:** • conduct an investigation with some guidance and use this to define a problem or design task in negotiation with the client • respond to the design specification using appropriate modelling and testing techniques to establish possible design solutions • produce a feasible design solution in response to the design specification taking account of feedback • evaluate the design against the design specification suggesting some improvements • contribute to effective teamwork.	**Learners:** • consistently use technical language relevant to the task • produce clear and accurate reports stating conclusions from results.

AS	Assessment Objective 1	Assessment Objective 2	Assessment Objective 3	Quality of Written Communication
E/U boundary performance description	**Learners:** • demonstrate the ability to recall and apply some knowledge from the specification; there may be significant omissions • demonstrate an understanding of some of the principles or concepts outlined in the specification and apply them to some familiar situations with guidance • carry out simple calculations with guidance sometimes obtaining the correct solutions with units.	**Learners:** • carry out investigations making and recording observations • demonstrate a limited evaluation of information from more than one source • compare some trends and patterns in data they have collected with standard data provided.	**Learners:** • investigate a problem or design task to be undertaken in negotiation with a client, guidance may be required throughout • respond to straightforward engineering situations or problems using basic modelling and testing techniques • produce a design solution that meets some of the requirements of the design specification • produce a basic analysis against the design specification • participate in teamwork.	**Learners:** • use some basic technical language relevant to the tasks • produce reports that are mostly clear and accurate but may have some omissions.

The performance descriptions for A2 indicate the level of attainment characteristic of A/B and E/U boundary learners. They give a general indicator of the required learning outcomes. The descriptions should be interpreted in relation to the content outlined in the specification; they are not designed to define the content. The grade awarded will depend in practice upon the extent to which the learner has met the Assessment Objectives overall. Shortcomings in some aspects of the examination may be balanced by better performance in others. The requirement for all AS and A2 specifications to assess learners' quality of written communication will be met through the Assessment Objectives.

The difference between the AS and A2 standard is determined by:

- the greater challenge presented by the A2 subject content
- the demands of the synoptic assessment
- more challenging Assessment Objective weightings at A2
- the differences spelt out in the following performance descriptions.

A2	Assessment Objective 1	Assessment Objective 2	Assessment Objective 3	Quality of Written Communication
Assessment Objective	Learners recall and apply knowledge, skills and understanding from across the specification content in a range of engineering situations.	Learners plan and carry out investigations and tasks in which they analyse engineering issues and problems and gather, record and analyse relevant information, data and other forms of evidence in a range of engineering situations.	Learners integrate knowledge, skills and understanding to independently analyse an engineering situation or problem; design, produce and communicate a response and evaluate outcomes and approach, making contributions to teamwork.	
A/B boundary performance description	**Learners:** • recall and apply knowledge and understanding from all parts of the specification with few omissions • consistently demonstrate an understanding of the principles and concepts outlined in the specification, and apply these to familiar and unfamiliar situations with minimal guidance • apply a range of mathematical and scientific principles, with minimal guidance, to solve engineering problems • carry out a wide range of calculations, with minimal guidance, usually obtaining the correct solutions with guidance.	**Learners:** • carry out investigations taking account of constraints, anticipating potential problems and identifying changes to plans or procedures • make and record appropriate observations and use them to evaluate procedures, techniques and equipment identifying limitations • evaluate a range of information sources selecting the most appropriate and justifying its selection • interpret trends and patterns in data explaining some inconsistencies and anomalies • demonstrate the ability to plan and manage the investigation or project in a logical and structured manner.	**Learners:** • conduct an independent investigation with minimal guidance and use this to define a problem or design task in negotiation with the client • respond to the design specification using appropriate modelling and testing techniques to establish possible design solutions • produce a feasible design solution in response to the design specification taking account of feedback • evaluate the design against the design specification, taking account of feedback, suggesting improvements where appropriate; design presentation is imaginative and effective • make a significant contribution to effective teamwork.	**Learners:** • consistently use appropriate technical language fluently • produce clear and accurate reports explaining conclusions from results and suggest where further evidence might be obtained.

A2	Assessment Objective 1	Assessment Objective 2	Assessment Objective 3	Quality of Written Communication
E/U boundary performance description	**Learners:** • demonstrate the ability to recall and apply some knowledge from the specification. There may be significant omissions • demonstrate an understanding of some of the principles or concepts outlined in the specification and apply these to familiar situations with guidance • apply straightforward mathematical and scientific principles, with guidance, to engineering problems sometimes obtaining the correct solutions with guidance • carry out straightforward calculations, where guidance is given, usually obtaining the correct solutions with guidance.	**Learners:** • carry out investigations making and recording appropriate observations • evaluate some information from more than one source • compare trends and patterns in data they have collected with standard data provided • demonstrate the ability to plan and manage some aspects of the investigation or project.	**Learners:** • investigate a problem or design task to be undertaken in negotiation with a client; guidance may be required throughout • respond to straightforward engineering situations or problems using modelling and testing techniques • produce a design solution that meets some of the requirements of the design specification • produce a basic analysis against the design specification, suggesting areas for improvement; design presentation conveys the learner's intention • actively participate in teamwork.	**Learners:** • use a range of technical language relevant to the task • produce reports that are mostly clear and accurate and provide some interpretation of their results.

Appendix C: Pearson Edexcel Level 3 GCE in Engineering — Witness Statement

Learner name:	
Unit title:	Learner number:

Activity context
Outline of the activity and its purpose.

The assessor or the learner, prior to observation, may write this.

Assessment evidence
Refer to the assessment grids produced from the specification.

Observation notes
Specific comments on learner performance that demonstrate achievement of the assessment evidence.

Assessor name:	Assessor signature:
	Date:

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For more information on Edexcel and BTEC qualifications
please visit our website: www.edexcel.com