WJEC Eduqas GCSE (9-1) in DESIGN AND TECHNOLOGY

For teaching from 2017
For award from 2019

This draft qualification has not yet been accredited by Ofqual. It is published to enable teachers to have early sight of our proposed approach to GCSE Design and Technology. Further changes may be required and no assurance can be given at this time that the proposed qualification will be made available in its current form, or that it will be accredited in time for first teaching in September 2017 and first award in 2019.

GCSE DESIGN AND TECHNOLOGY

SUMMARY OF ASSESSMENT

Component 1: Design and Technology in the 21st Century
Written examination: 2 hours
50% of qualification

A mix of short answer, structured and extended writing questions assessing candidates' knowledge and understanding of:

- technical principles
- designing and making principles

along with their ability to

- analyse and evaluate design decisions and wider issues in design and technology.

Component 2: Design and make task
Non-exam assessment: approximately 35 hours
50% of qualification

A sustained design and make task, based on a contextual challenge set by WJEC, assessing candidates' ability to:

- identify, investigate and outline design possibilities
- design and make prototypes
- analyse and evaluate design decisions and wider issues in design and technology.

This linear qualification will be available for assessment in May/June each year. It will be awarded for the first time in summer 2019.

Qualification Accreditation Number: -------

GCSE DESIGN AND TECHNOLOGY

1 INTRODUCTION

1.1 Aims and objectives

The WJEC Eduqas GCSE in Design and Technology offers a unique opportunity in the curriculum for learners to identify and solve real problems by designing and making products or systems. Through studying GCSE Design and Technology, learners will be prepared to participate confidently and successfully in an increasingly technological world; and be aware of, and learn from, wider influences on design and technology, including historical, social/cultural, environmental and economic factors.

The specification enables learners to work creatively when designing and making and apply technical and practical expertise, in order to:

- demonstrate their understanding that all design and technological activity takes place within contexts that influence the outcomes of design practice
- develop realistic design proposals as a result of the exploration of design opportunities and users' needs, wants and values
- use imagination, experimentation and combine ideas when designing
- develop the skills to critique and refine their own ideas whilst designing and making
- communicate their design ideas and decisions using different media and techniques, as appropriate for different audiences at key points in their designing
- develop decision making skills, including the planning and organisation of time and resources when managing their own project work
- develop a broad knowledge of materials, components and technologies and practical skills to develop high quality, imaginative and functional prototypes
- be ambitious and open to explore and take design risks in order to stretch the development of design proposals, avoiding clichéd or stereotypical responses
- consider the costs, commercial viability and marketing of products
- demonstrate safe working practices in design and technology
- use key design and technology terminology including those related to: designing, innovation and communication; materials and technologies; making, manufacture and production; critiquing, values and ethics

1.2 Prior learning and progression

There are no previous learning requirements for this specification. Any requirements set for entry to a course based on this specification are at the school/college's discretion.

This specification builds on subject content which is typically taught at key stage 3 and provides a suitable foundation for the study of design and technology at either AS or A level. In addition, the specification provides a coherent, satisfying and worthwhile course of study for learners who do not progress to further study in this subject.

1.3 Equality and fair access

This specification may be followed by any learner, irrespective of gender, ethnic, religious or cultural background. It has been designed to avoid, where possible, features that could, without justification, make it more difficult for a learner to achieve because they have a particular protected characteristic.

The protected characteristics under the Equality Act 2010 are age, disability, gender reassignment, pregnancy and maternity, race, religion or belief, sex and sexual orientation.

The specification has been discussed with groups who represent the interests of a diverse range of learners, and the specification will be kept under review.

Reasonable adjustments are made for certain learners in order to enable them to access the assessments (e.g. candidates are allowed access to a Sign Language Interpreter, using British Sign Language). Information on reasonable adjustments is found in the following document from the Joint Council for Qualifications (JCQ): *Access Arrangements and Reasonable Adjustments: General and Vocational Qualifications.*

This document is available on the JCQ website (www.jcq.org.uk). As a consequence of provision for reasonable adjustments, very few learners will have a complete barrier to any part of the assessment.

2 SUBJECT CONTENT

The subject content is presented under two headings: *technical principles* and *designing and making principles*. Within each area, the content is further divided into *core knowledge and understanding* and *in-depth knowledge and understanding.*

The specification content and assessment requirements are designed to ensure learners develop an appropriate breadth and depth of knowledge and understanding in design and technology.

2.1 Technical principles

Core knowledge and understanding is presented in five clear and distinct topic areas:

- design and technology and our world
- smart materials
- electronic systems and programmable components
- mechanical components and devices
- materials

Learners are required to study all of the content in these five areas, to ensure they have a broad knowledge and understanding of design and technology and that they are able to make effective choices in relation to which materials, components and systems to utilise within design and make activities.

In-depth knowledge and understanding is presented in six clear and distinct topic areas:

a. electronic systems, programmable components & mechanical devices
b. papers & boards
c. natural & manufactured timber
d. ferrous & non-ferrous metals
e. thermoforming & thermosetting polymers
f. fibres & textiles

Learners are required to study at least one of these six areas, to ensure they have an in-depth knowledge and understanding of a specific material area and/or components and systems to support their design and make activities.

All topics within the core knowledge and understanding, the in-depth knowledge and understanding, and designing and making principles must be addressed. In each case, the left hand column identifies the content topic and the amplification indicates the areas that need to be covered. The amplification column provides more information on the content presented in the left hand column, including the breadth and depth of study required. Centres are not restricted to how they will deliver this to the learner but it is anticipated that there will be an integrated approach between the core and the in-depth content.

2.2 Designing and making principles

Core knowledge and understanding that learners are required to develop and apply is presented in ten clear topic areas:

- understanding design and technology practice
- understanding user needs
- writing a design brief and specifications
- investigating challenges
- developing ideas
- investigating the work of others
- using design strategies
- communicating ideas
- developing a prototype
- making decisions

Learners are required to cover all of the content in these ten areas, to ensure they are able to apply a broad knowledge and understanding of design and technology principles within design and make activities.

In-depth knowledge and understanding is presented in five clear topic areas:

- selecting and working with materials and components
- marking out
- using tools and equipment
- using specialist techniques
- using surface treatments and finishes

Learners are required to cover all of the content in these five areas, **in relation to at least one of the topic areas (a to f)** identified in the in-depth knowledge and understanding section of technical principles.

The content structure of this GCSE design and technology specification is illustrated below.

Technical principles		
Core knowledge & understanding		In-depth knowledge & understanding
• Design and technology and our world • Smart materials • Electronic systems and programmable components • Mechanical components and devices • Materials	Plus at least one from	**a.** Electronic systems, programmable components & mechanical devices **b.** Papers & boards **c.** Natural & manufactured timber **d.** Ferrous & non-ferrous metals **e.** Thermosetting & thermoforming plastics **f.** Fibres & textiles

Designing and making principles		
Core knowledge & understanding	Plus	In-depth knowledge & understanding (in relation to at least one of **a** to **f** above)

There is no hierarchy implied in the order in which the content is presented and it does not imply a prescribed teaching order.

The subject content for GCSE Design and Technology will be assessed in the written examination and non-exam assessment (NEA).

Design and Technology in the 21st Century
Written examination: 2 hours
50% of qualification
100 marks

Design and make task
NEA: approximately 35 hours
50% of qualification
100 marks

Calculators may be used in Component 1 and in Component 2. Learners are responsible for making sure that their calculators meet the relevant regulations for use in written examinations: information is found in the JCQ publications *Instructions for conducting examinations* and *Information for candidates for written examinations.*

2.1 Technical principles

Technical principles **Core knowledge and understanding**
This section is designed to develop learners' knowledge and understanding in design and technology and its impact on daily life. Learners should develop a broad understanding of materials, systems and processes and have the opportunity to apply knowledge and understanding from other subject areas including mathematics and science. Appendix B illustrates links to relevant mathematics and science skills. These must be covered within GCSE Design and Technology qualifications and will be assessed in this qualification in Component 1.

Design and technology and our world	
Learners need a breadth of technical knowledge and understanding in order to make effective choices in relation to the selection of materials, components and systems. They should consider emerging technologies, environmental issues and impacts on society. They should consider the needs of future generations as well as their own, and take a broad view of the impact of design and technology activities.	
Content	Amplification

1. The impact of new and emerging technologies on:
• industry
• enterprise
• sustainability
• people
• culture
• society
• the environment
• production techniques
• systems
	The focus of this content is the impact of new and emerging technologies on the areas identified below.
	
	• The impact of new and emerging technologies on industry and enterprise, including:
	  • market pull – responding to demands from the market;
	  • technology push – development in materials and components, manufacturing methods;
	  • consumer choice – consumers wishing to own the latest technologies/products.
	• The Product Life Cycle.
	• Global production and its effects on culture and people.
	• Legislation to which products are subject.
	• Consumer rights and protection for consumers when purchasing and using products.
	• Moral and ethical factors related to manufacturing products and the sale and use of products.
	• Sustainability; meeting today's needs without compromising the needs of future generations.
	• Advantages and disadvantages of using computer aided design (CAD).
	• Advantages and disadvantages of the use of computer aided manufacture (CAM).
	• How CAM equipment can be used in a variety of applications, including: CNC embroidery, vinyl cutting, CNC routing, laser cutting and 3D printing.

Content	Amplification
2. How the critical evaluation of new and emerging technologies informs design decisions; considering contemporary and potential future scenarios from different perspectives, such as ethics and the environment	The focus of this content is how the critical evaluation of new and emerging technologies informs design decisions. • The importance of sustainability issues and environmental issues when designing and making. • Social, cultural, economic and environmental responsibilities in designing and making products. • The SIX R's of sustainability; rethink, reuse, recycle, repair, reduce and refuse. • Life Cycle Analysis to determine the environmental impact of a product. • Fair-trade policies and carbon footprint. • Ecological footprint.
3. How energy is generated and stored in order to choose and use appropriate sources to make products and to power systems	• Types of renewable and non-renewable energy sources including: wind, solar, geothermal, hydroelectric, wood/biomass, wave, coal, gas, nuclear and oil. • Issues surrounding the use of fossil fuels including coal, oil and gas. • The advantages and disadvantages of renewable energy sources. • The use of renewable energy sources in modern manufacturing production systems including the use of solar panels and wind turbines in manufacturing sites. • Renewable energy sources for products including wind-up and photovoltaic cells. • Energy generation and storage in a range of contexts including motor vehicles (e.g. petrol/diesel, electricity) and household products (e.g. battery, solar, mains electricity).

Smart materials, composites and technical textiles	
The design and manufacture of products depends upon material technology and the development and implementation of materials in products. Learners need to be aware of developments in materials technology and how these impact on the design and use of products.	
Content	Amplification

4. Developments in modern and smart materials, composite materials and technical textiles	• Electroluminescent film or wire i.e. LCD.
	• Quantum Tunnelling Composite (QTC) - when used in circuits the resistance changes under compression.
	• SMA – shape memory alloys.
	• Polymorph.
	• Smart fibres and fabrics that respond to the environment or stimuli:
	  ◦ photo-chromic;
	  ◦ thermo-chromic;
	  ◦ micro-encapsulation;
	  ◦ biometrics.
	• Carbon Fibre, Kevlar and GRP.
	• Interactive textiles that function as electronic devices and sensors: circuits integrated into fabrics, such as heart rate monitors; wearable electronics such as mobile phones or music player, GPS, tracking systems and electronics integrated into the fabric itself.
	• Micro-fibres in clothing manufacture.
	• Phase changing materials: breathable materials; proactive heat and moisture management.
	• Sun protective clothing.
	• Nomex.
	• Geotextiles for landscaping.
	• Rhovyl as an antibacterial fibre.

Electronic systems and programmable components	
Familiar products often include the use of electronic components. Learners should be aware of the importance of electronic and programmable components to the product designer and end user and how such components are integrated into everyday products we use.	
Content	Amplification

5. How electronic systems provide functionality to products and processes, including sensors and control devices to respond to a variety of inputs, and devices to produce a range of outputs	• Graphical conventions for communicating concepts including circuit diagrams, block diagrams and flowcharts.
	• The 'systems' approach – input; process; output.
	• Principles of a control system:
	  ◦ input data from a sensor: light dependent resistor (LDR), thermistor;
	  ◦ processing by control devices including semi-conductor, IC, microprocessor or computer;
	  ◦ output where a signal is received that will perform a desired function: buzzer, light emitting diode (LED).
	• The importance of feedback within the system.
	• The methods of providing feedback in different systems.
	• Familiar products in terms of their control system.
	• Control devices that include counting, switching and timing.
	• Analogue and digital sensors as input components.

6. The use of programmable components to embed functionality into products in order to enhance and customise their operation	• Sub routines or macros in control systems. • Programmable microcontrollers can be used to control a range of systems. • Programmable microcontrollers can interface with other devices. • Programmable microcontrollers can be reprogrammed repeatedly. • The benefits and limitations of programmable microcontrollers. • Programmable Interface Controllers (PIC) and how they can be used to control products or systems.

<table>
<tr><th colspan="2">Mechanical components and devices</th></tr>
<tr><td colspan="2">Familiar products often include the use of mechanical components and devices. Learners should be aware of the importance of mechanical components and devices to the product designer and end user and how such components are integrated into everyday products we use.</td></tr>
<tr><td>Content</td><td>Amplification</td></tr>
<tr><td>7. The functions of mechanical devices, to produce different sorts of movement, changing the magnitude and direction of forces</td><td>

Principle of a mechanical device to transform input motion and force into a desired output motion and force.
Analyse everyday mechanical devices and how they function.
Consider mechanical systems in terms of input; process; output.

Mechanical systems which:

increase or decrease speed of movement/rotation;
change magnitude/direction of force/movement/rotation.

Simple calculations involving mechanical systems.

Analyse the function of mechanical products that have:

pulley systems, for example curtain rails, sewing machine;
gear systems, for example whisk, hand drill;
levers and linkages, for example scissors;
rack and pinion, for example chair lift;
cams, for example automata toys.

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Materials	
Learners need to have a broad understanding of the categorisation and properties of a range of materials. They should be aware of their source, use and application in products.	
Content	Amplification
8. Papers and boards	• The categorisation and properties of paper, cards, boards and composite materials. Properties to be considered in terms of their strength, folding ability, surface finish and absorbency. • Papers, cards and boards can be laminated to improve strength, finish and appearance. • The standard ISO sizes of paper. • The use of grammage i.e. grams per square metre (gsm) to measure weight of paper. • The use of microns to measure thickness of card. • The use of recycled materials to manufacture papers and boards. • The aesthetic and functional properties of common papers, cards and boards including: layout paper, tracing paper, copier paper, recycled paper, corrugated board, cartridge paper, mounting board and folding boxboard.
9. Natural and manufactured timber	• The categorisation and properties of hardwoods and softwoods. • Properties to be considered: strength, grain structure, surface finish and absorbency. • Natural timber is harvested from deciduous (hardwoods) and coniferous (softwood) trees. • Natural timber is available in the following forms: plank, board, strip, square, and dowel. • Natural timber can be identified using a range of discriminators including weight, colour, grain, texture, durability and ease of working. • Natural timber is protected using different finishes and these finishes are sometimes used to improve aesthetic appeal. • Categorisation and properties of manufactured timbers. • Manufactured timbers are made from natural timbers and made from particles/fibres or laminates. • Manufactured timbers are available in standard sizes and forms including plywood, MDF (Medium Density Fibreboard), chipboard, hardboard and veneered boards. • Manufactured timbers can be protected using finishes and these finishes are sometimes used to improve the aesthetic appeal.

10. Ferrous and non-ferrous metals	• Categorisation and working properties of ferrous metals, non-ferrous metals and alloys. • Properties of metals including hardness, elasticity, conductivity, toughness, ductility, tensile strength and malleability. • Metals are sold as sheet, bar, rod, tube and angle. • Ferrous metals including cast iron, mild steel, medium carbon steel and high carbon steel. • Ferrous metals may require a protective finish and the finish is sometimes used to improve the aesthetic appeal. • Non-ferrous metals including aluminium, copper, brass, bronze. • Alloys of metals are a base metal mixed with other metals or non-metals to change their properties or appearance. • Non-ferrous metals may require a protective finish and the finish is sometimes used to improve the aesthetic appeal.
11. Thermoforming and thermosetting polymers	• Categorisation and physical properties of polymers. • Polymers can be made from both natural and synthetic resources. • Polymers are sold as sheet, film, bar, rod and tube. • The differences between a thermoforming (thermoplastic) and thermosetting material. • Properties of polymers including weight, hardness, elasticity, conductivity/insulation, toughness and strength. • The properties of thermoplastics including polythene, polystyrene, polypropylene and PVC. • The properties of the thermosetting plastics including, UF (urea formaldehyde), MF (melamine formaldehyde), PR (polyester resin) and ER (epoxy resin).

12. Natural, synthetic, blended and mixed fibres, and woven, non-woven and knitted textiles.	• The categorisation and working properties of fibres and textiles.
	• The raw materials of textiles are classified according to their source.
	• Natural polymers:
	    • Animal polymers: wool/fleece – mohair, cashmere, angora, alpaca, camel (hair).
	    • Insect polymers: silk.
	    • Plant polymers: cotton, linen hemp, jute, rayon, viscose.
	• Manufactured polymers:
	    • Synthetic: polyester, polypropylene, nylon, elastane, lycra, aramid fibres.
	    • Microfibres – Tactel, Tencel (Lyocell).
	• The properties of textiles fibres including, strength, elasticity, absorbency, durability, insulation, flammability, water-repellence, anti-static and resistance to acid, bleach and sunlight.
	• Blending and mixing fibres improves the properties and uses of yarns and materials.

Technical principles **In-depth knowledge and understanding**
Learners are required to develop an in-depth knowledge and understanding in relation to **at least one** of the following: • electronic systems, programmable components & mechanical devices. • papers & boards. • natural & manufactured timber. • ferrous & non-ferrous metals. • thermoforming & thermosetting polymers. • natural, synthetic, blended and mixed fibres; woven, non-woven and knitted textiles.

In-depth knowledge and understanding

This section is for electronic systems, programmable components & mechanical devices.

Learners are required to develop an in-depth knowledge and understanding of:

	Content	Amplification
Electronic systems, programmable components & mechanical devices	**1.** The sources, origins, physical and working properties of the material categories or the components and systems, and their ecological and social footprint	Components and how they can be combined to from a system or sub-system. **Functions of electronic and programmable devices / systems** • Voltage, Resistance and Current and their relationship in an electronic circuit. • Ohm's Law: V=I*R. • Function of resistors and their colour code system. • Electronic circuits / systems in terms of input, process and output blocks. • Use of a relay. **Input Devices** • Including SPST, SPDT, DPDT, push to make, push to break, reed, and tilt switches. • Sensors for light, heat and moisture, including the LDR and the thermistor in a potential divider. **Process Components** • The transistor to control a switching or sensing circuit; as a switch, amplifier, transducer driver. • ICs to control monostable time delays. • ICs to control astable pulse generators, multi-vibrators, comparators and amplifiers. • Controlling a time delay and pulse frequency. • The capacitor and its role in timing circuits. • The function of a thyristor or silicon controlled rectifier as a latching device.

<table>
<tr>
<td rowspan="2">Electronic systems, programmable components & mechanical devices</td>
<td>1. The sources, origins, physical and working properties of the material categories or the components and systems, and their ecological and social footprint (cont.)</td>
<td>Operational amplifiers and gain.
• Programmable micro controllers to control a variety of input and output devices.
• The function of AND, OR, EOR, NOT, and NAND logic gates.
• Combining logic gates to form control systems.

Output Components
• Including lamps, LEDs, buzzers, piezo sounders, loudspeakers, sirens, motors and solenoids.

Functions of mechanical devices / systems
• Simple and compound pulley and belt systems.
• Calculate velocity ratio.
• RV of driver*dia of driver= RV of driven*dia of driven.
• Simple and compound gear systems.
• Calculate velocity ratio.
• RV of driver*teeth on driver= RV of driven*teeth on driven.
• Worm drive systems.
• Bevel gear systems.

Levers
• Classification.
• Calculation of mechanical advantage.
• Calculate forces acting in simple lever systems using the principle of moments.

Others
• Rack and Pinion.
• Pawl and Ratchet.
• Crank and Slider.
• Cams.

Ecological and social footprint
• Changing society's view on waste, encourage recycling.
• Living in a greener world.
• Life-cycle analysis of a material or product.
• Sustainable design, e.g. with reference to rapidly updated products such as mobile phones.</td>
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<tr>
<td>2. The way in which the selection of materials or components is influenced by a range of factors, such as functional, aesthetic, environmental, availability, cost, social, cultural and ethical</td>
<td>• Components and their functional benefits or limitations.
• Miniaturisation to reduce the size of control systems, or the number of components for functional or cost reasons.
• Cultural, social, ethical and environmental responsibilities of designers and manufacturers with respect to: material/component selection should not be harmful to people or the environment; working conditions; recyclability and waste.</td>
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Electronic systems, programmable components & mechanical devices	**3.** The impact of forces and stresses on materials and objects and the ways in which materials can be reinforced and stiffened	• How mechanical components are strengthened to withstand forces. • Casing and protecting electronic components.
	4. Stock forms, types and sizes in order to calculate and determine the quantity of materials or components required	• Standard stock electronic components sizes. • Dual In Line (DIL) standard for electronic ICs. • Stock materials for the manufacture of products. • Calculate cost of materials and components for products.
	5. Alternative processes that can be used to manufacture products to different scales of production	• Mass production. • Just in time manufacturing. • The use of CAD/CAM in production. • Batch production. • Jigs and devices to control repeat activities. • One-off production.
	6. Specialist techniques and processes that can be used to shape, fabricate, construct and assemble a high quality prototype, including techniques such as wastage, addition, deforming and reforming, as appropriate to the materials and/or components being used	**Wastage/Addition** • Appropriate tools and equipment to mark out, hold, cut, shape, drill and form materials. • The pillar drill to drill holes to various diameters. • Jigs and formers to ensure accuracy. **Deforming/Reforming** • Bending plastics. • Hot/cold working of sheet metals, casting. • Drilling and turning materials. • Vacuum forming, moulding. • Laser cutting. • 3D printing. **Assembly and components** • Components for a particular purpose, including nuts, bolts, washers, screws, rivets. • Joining components together, e.g. soldering components to circuit boards. • Joining materials - mechanical or chemical bond. • Joining like and unlike materials together. • Material joining - permanent and temporary.
	7. Appropriate surface treatments and finishes that can be applied for functional and aesthetic purposes	• Temporary and permanent fixings of circuits for assembly and protection of components. • Surface finishes applied to electronic devices for functional or aesthetic purposes. • Powder and plastics coating of metals.

In-depth knowledge and understanding

This section is for papers and boards.
Learners are required to develop an in-depth knowledge and understanding of:

Papers and boards

Content	Amplification
1. The sources, origins, physical and working properties of the material categories or the components and systems, and their ecological and social footprint	• How wood pulp is made. • The differences between mechanical and chemical wood pulp. • Recycled paper. • How paper is made by hand. • Surface finishes of paper and card. • Commercial manufacture of papers and boards. • The physical and working properties of paper and board including: texture, weight, thickness, strength, surface finish, transparency, folding ability and absorbency. **Ecological and social footprint:** • The impact on the environment. • Greenhouse gases. • Changing society's view on waste, encourage recycling of all materials. • Living in a greener world. • Packaging – is it always needed? • Life-cycle analysis of a material or product. • Sustainable design.

2. The way in which the selection of materials or components is influenced by a range of factors, such as functional, aesthetic, environmental, availability, cost, social, cultural and ethical	• Aesthetic and functional properties of cards and boards.
	• Advantages and disadvantages of common paper, card and boards for commercial and everyday use, including: layout paper, tracing paper, copier paper, recycled paper, cartridge paper, mounting board, folding boxboard and corrugated board.
	• The reasons for use of paper, card and boards in everyday products.
	• The aesthetic properties of paper, card and boards.
	• Responsibilities of designers and manufacturers who design using paper card with respect to:
	  ◦ the environment;
	  ◦ working conditions in third world countries, low labour costs and poverty;
	  ◦ exploitation of employees;
	  ◦ recyclability and waste;
	  ◦ biodiversity and deforestation.
	• Estimating the true costs of a prototype or product.

3. The impact of forces and stresses on materials and objects and the ways in which materials can be reinforced and stiffened	• The behaviour of papers and board under forces or stress. • Reinforcement of papers and boards by corrugating, folding, gluing. • Stiffening papers and boards by increasing thickness, adding ribs. • Structural integrity, stiffness and strength of papers and card boards by laminating and the design of the cross-section of the board, for example corrugated card board has a fluted core between two layers of card. • The strength of paper and boards in products will depend upon the design and the joining or fixing methods used.

Papers and boards	**4.** Stock forms, types and sizes in order to calculate and determine the quantity of materials or components required	• Standard sizes of papers and boards. i.e. rolls, A5, A4, A3. • Paper is measured in grams per square metre. • Cardboard is available in different forms with different cores. • Costs and how to calculate the cost of materials for different forms of products.

	5. Alternative processes that can be used to manufacture products to different scales of production	• Advantages and disadvantages of producing single, one off products.
		• The advantages and disadvantages of producing products in limited quantities (batch production).
		• The need to produce a number of identical products.
		• Jigs and devices to control repeat activities.
		• The advantages and disadvantages of high volume, continuous production.
		• Issues related to high volume production.
		• The importance of CAM in modern high volume production.
		• Pre-press, on-press and the finishing processes used by commercial printers to produce products in batches or mass/high volume.
		• Pre-press operations including:
		  ◦ Grids, registration marks, layout, imposition and colour separation;
		  ◦ On-press operations;
		  ◦ Finishing Processes;
		  ◦ Die cutting, spirit varnishing, and UV varnishing, laminating, embossing, debossing, cropping, folding and binding methods;
		  ◦ Techniques used to produce books, magazines, leaflets, flyers, packages and other printed products.

Papers and boards	**6.** Specialist techniques and processes that can be used to shape, fabricate, construct and assemble a high quality prototype, including techniques such as wastage, addition, deforming and reforming, as appropriate to the materials and/or components being used	**Wastage/Addition** • Tools and equipment to mark out, hold, cut, shape, drill, form laminates of plastics, papers/boards. • Marking out materials using a range of workshop tools. • Jigs and formers to ensure accuracy as part of the process of drilling, bending, cutting and forming. **Deforming/Reforming** • Bending plastics. • Vacuum forming. • Laser cutting. • 3D printing. • Press forming / moulding. • Blow moulding. • CAM machines. • 3D Printers. • Score and fold paper and card. • Assembly and components. • Components for a particular purpose. • Material joining - permanent and temporary.
	7. Appropriate surface treatments and finishes that can be applied for functional and aesthetic purposes	• The application of a variety of finishing materials. • Die cutting, spirit varnishing, U.V. varnishing, laminating, embossing, debossing, cropping, folding and binding methods. • The use and importance of product labelling and symbolic images that convey messages.

<table>
<tr><th colspan="3">In-depth knowledge and understanding</th></tr>
<tr><td colspan="3">This section is for natural and manufactured timber.

Learners are required to develop an in-depth knowledge and understanding of:</td></tr>
<tr><td></td><td>Content</td><td>Amplification</td></tr>
<tr><td rowspan="3">Natural and manufactured timber</td><td>1. The sources, origins, physical and working properties of the material categories or the components and systems, and their ecological and social footprint</td><td>• The physical and working properties of hardwoods, softwoods and man-made boards: toughness, flexibility, grain structure, strength, absorbency, surface finish, colour and hardness.
• Natural solid timber - strengths and weaknesses
• Defects including: shrinkage, splits, shakes, knots, fungial attack.
• Hardwoods including beech, oak, mahogany, balsa and jelutong.
• Softwoods including scots pine, western red cedar and parana pine.
• Strengths, weaknesses of the following manufactured boards:
    • plywood, MDF - medium density fibreboard, chipboard and hardboard.
• The impact on the environment of deforestation.
• Ecological and social footprint.
• Changing society’s view on waste, encourage recycling.
• Living in a greener world.
• Life-cycle analysis of a material or product.</td></tr>
<tr><td>2. The way in which the selection of materials or components is influenced by a range of factors, such as functional, aesthetic, environmental, availability, cost, social, cultural and ethical</td><td>• Aesthetic properties of natural and manufactured timbers.
• Functional properties of natural and manufactured timbers.
• Responsibilities of designers and manufacturers who design using timber with respect to:
    • the environment;
    • working conditions in third world countries, low labour costs and poverty;
    • exploitation of employees;
    • recyclability and waste.
• Biodiversity and deforestation.
• Estimating the true costs of a prototype or product.
• Comparison costs of hardwoods, softwoods and manufactured board.</td></tr>
<tr><td>3. The impact of forces and stresses on materials and objects and the ways in which materials can be reinforced and stiffened</td><td>• The behaviour of natural and manufactured timber under forces or under stress.
• The stiffness and a strength of natural timber will depend upon the wood, the cross sectional area and the depth of the section.
• Reinforcement of natural timber by laminating.
• The strength of plywood will depend upon the number of layers and the wood grain being at right angles.
• The strength of a timber product will depend upon how the product is jointed or what fixing method is used.</td></tr>
</table>

Natural and manufactured timber		
	4. Stock forms, types and sizes in order to calculate and determine the quantity of materials or components required	• Natural timber is available in different sectional forms, various standard sizes and can have a different finish (sawn or planed). • Manufactured boards are commonly available in sheet form and in standard sizes and various thicknesses. • Calculate the costs involved in the design of products including, fixtures, fittings, finishes required and the material cost.
	5. Alternative processes that can be used to manufacture products to different scales of production	• Advantages and disadvantages of producing single, one off products. • The advantages and disadvantages of producing products in limited quantities (batch production). • The need to produce a number of identical products. • Jigs and devices to control repeat activities. • The advantages and disadvantages of high volume, continuous production. • Issues related to high volume production. • The importance of CAM in modern high volume production.
	6. Specialist techniques and processes that can be used to shape, fabricate, construct and assemble a high quality prototype, including techniques such as wastage, addition, deforming and reforming, as appropriate to the materials and/or components being used	**Wastage/Addition** • Tools and equipment to mark out, hold, cut, shape, drill and form laminates of natural timbers and manufactured boards. • The pillar drill to drill holes to various diameters. • Jigs and formers to ensure accuracy as part of the process of drilling, bending, cutting wood materials. **Deforming/Reforming** • Material joining can be permanent or temporary. • The principles of producing wood products using the following processes: jointing, veneering, laminating and steam bending. • Classification of wood joints as frame or box construction. • Frame: mitre, dowel, mortise and tenon, halving and bridle joint. • Box/carcass: butt, lap, housing, dovetail and comb joint. • Adhesives: PVA (wood to wood), contact adhesive and epoxy resin (wood to other materials). • Temporary: screw (countersunk and round head) and knock down fittings. • Lasers. • CAM machines.
	7. Appropriate surface treatments and finishes that can be applied for functional and aesthetic purposes	• Surface treatments of natural timber and manufactured boards to prolong life of a product: sealants and primers. • Finishes for aesthetic or functional reasons: varnish, wood stains, oils, polishes and preservative paints.

In-depth knowledge and understanding

This section is for ferrous and non-ferrous metals.

Learners are required to develop an in-depth knowledge and understanding of:

	Content	Amplification
Ferrous and non-ferrous metals	**1.** The sources, origins, physical and working properties of the material categories or the components and systems, and their ecological and social footprint	• Classification as ferrous metals, non-ferrous metals and alloys. • Metals are soured from ores and are a natural resource. **Ferrous Metals** • Strengths and weaknesses. • Cast iron, mild steel, medium carbon steel and high carbon steel. • Stainless steel, high-speed steel and high-tensile steel. • Physical properties of metals including: melting point, thermal and electrical conductivity. • Mechanical properties of metals including: tensile strength, toughness, plasticity, malleability and hardness. **Non-Ferrous Metals** • Strengths and weaknesses. • Aluminium, duralumin, copper, brass, bronze, pewter and silver. • Heat treatment of metals including: annealing, normalising, hardening, tempering and case hardening. • Physical properties of metals including: melting point, thermal and electrical conductivity. • Mechanical properties of metals including: tensile strength, toughness, plasticity, malleability and hardness. **Ecological and social footprint:** • The impact on our environment of mining for ores. • Greenhouse gases during the production of metals. • Changing society's view on waste, encouraging recycling of metals. • Living in a greener world. • Life-cycle analysis of a material or product.

	2. The way in which the selection of materials or components is influenced by a range of factors, such as functional, aesthetic, environmental, availability, cost, social, cultural and ethical	• Aesthetic and functional properties of the following: aluminium, duralumin, copper, brass, bronze, pewter, silver, cast iron, mild steel and medium carbon steel.
		• Responsibilities of designers and manufacturers who design using metals with respect to:
		  • the environment;
		  • working conditions in third world countries, low labour costs and poverty;
		  • exploitation of employees;
		  • recyclability and waste.
		• Biodiversity.
		• Estimating the true costs of a prototype or product.

Ferrous and non-ferrous metals	**3.** The impact of forces and stresses on materials and objects and the ways in which materials can be reinforced and stiffened	• The ability of a metal to withstand forces will depend upon the type of metal and the natural ability of the metal to be hardened or tempered by the action of heat. • The stiffness and strength of metals will depend upon the metal's natural properties, stock form, cross sectional area and the depth of the section.
	4. Stock forms, types and sizes in order to calculate and determine the quantity of materials or components required	• Metals are available in a number of common forms including: (round) rod, square rod, hexagonal rod, strip, sheet, round tube, square tube, angle and channel. • Sizes of metals are normally related to their cross section and are available in stock lengths. • Costs and how to calculate the cost of metals for different forms of products.
	5. Alternative processes that can be used to manufacture products to different scales of production	• Manufacturing systems, including one off, batch and high volume production. • Manufacturing systems, the advantages and disadvantages of producing single, one off products. • The advantages and disadvantages of producing products in limited quantity (batch production). • Jigs and devices to control repeat activities. • The advantages and disadvantages of high volume, continuous production. • Issues related to high volume production. • Commercial production line and its features. • The importance of CAM in modern high volume production.

Ferrous and non-ferrous metals	**6.** Specialist techniques and processes that can be used to shape, fabricate, construct and assemble a high quality prototype, including techniques such as wastage, addition, deforming and reforming, as appropriate to the materials and/or components being used	**Wastage/Addition**
		• Cutting metals to the required shape or contour.
		• Tools and equipment to mark out, hold, cut, shape, drill and form metals.
		• The pillar drill to drill holes to various diameters.
		• Jigs and formers to ensure accuracy as part of the process of drilling.
		• Pilot, clearance, tapping, countersunk and counterbored holes.
		• Work hardening and annealing.
		• Case hardening of mild steel and hardening and tempering tool steel.
		
		Deforming/Reforming
		• Metal joining can be permanent or temporary, by welding, soldering and the use of nuts, bolts, washers, screws, rivets, hinges, catches.
		• Lathe to turn materials.
		• Milling machine to create a slot or face edge.
		• The main stages in the following joining processes:
		  ◦ Permanent: riveting, welding, brazing, silver soldering and use of epoxy resins.
		  ◦ Temporary: screws, nuts, bolts.
		• Lasers.
		• CAM machines.

	7. Appropriate surface treatments and finishes that can be applied for functional and aesthetic purposes	• Metal surface treatments finishing processes: plastic coating, enamelling, oil finishing black steel, paint and primer.

<table>
<tr><td colspan="3">In-depth knowledge and understanding</td></tr>
<tr><td colspan="3">This section is for thermosetting and thermoforming plastics.

Learners are required to develop an in-depth knowledge and understanding of:</td></tr>
<tr><td></td><td>Content</td><td>Amplification</td></tr>
<tr><td rowspan="2">Thermosetting and thermoforming plastics</td><td>1. The sources, origins, physical and working properties of the material categories or the components and systems, and their ecological and social footprint</td><td>• Natural and synthetic plastic.
• Polymers and the polymerisation process.
• Common thermoplastics, their strengths, weaknesses and working properties, including: acrylic, polythene, PVC, polypropylene, polycarbonate, styrofoam, expanded polystyrene and nylon.
• Common thermosetting plastics, their strengths, weaknesses and working properties, including: urea formaldehyde, melamine and epoxy resins.
• Physical properties of plastics including: thermal conductivity and electrical conductivity/insulation.
• Mechanical properties of plastics including: tensile strength, toughness, plasticity, malleability and hardness.

Ecological and social footprint:
• The impact on our environment of oil exploration and extraction.
• Greenhouse gases during the extraction and production of polymer plastics.
• Changing society’s view on waste, encourage recycling of all plastics.
• Living in a greener world.
• Life-cycle analysis of a material or product.</td></tr>
<tr><td>2. The way in which the selection of materials or components is influenced by a range of factors, such as functional, aesthetic, environmental, availability, cost, social, cultural and ethical</td><td>• Aesthetic and functional properties and the advantages and disadvantages plastics in everyday products.

• Responsibilities of designers and manufacturers who design using plastics with respect to:
  • the environment;
  • working conditions in third world countries, low labour costs and poverty;
  • exploitation of employees;
  • recyclability and waste.
  • biodiversity.
• Estimating the true costs of a prototype or product.
• New polymers are being developed often for specific purposes including: biodegradability and compostability.</td></tr>
</table>

Thermosetting and thermoforming plastics	**3.** The impact of forces and stresses on materials and objects and the ways in which materials can be reinforced and stiffened	• The behaviour of thermoforming and thermosetting plastics under forces or stress. • The stiffness and a strength of thermoforming and thermosetting plastic polymers depends upon the type of plastic, the cross sectional area and the depth of the section. • Thermoforming and thermosetting plastic polymers can be strengthened by laminating. • Different forms of fibres can affect the strength of thermosetting plastics and act as reinforcement.
	4. Stock forms, types and sizes in order to calculate and determine the quantity of materials or components required	• Polymers are available in expanded forms including: open cell – foams; closed cell - expanded plastics. • Plastic polymers are available in a wide range of forms including: powders, granules, pellets, liquids, films, sheets and extruded shapes. • Calculate material costs for products.
	5. Alternative processes that can be used to manufacture products to different scales of production	• Advantages and disadvantages of producing single, one off products. • The advantages and disadvantages of producing products in limited quantities (batch production). • The need to produce a number of identical products. • Jigs and devices to control repeat activities. • The advantages and disadvantages of high volume, continuous production. • The importance of CAM in modern high volume production. • A range of products suitable for high volume, continuous production. • The principles of producing plastic products and components using the following processes: • blow moulding, vacuum forming, press moulding and compression moulding.

Thermosetting and thermoforming plastics	**6.** Specialist techniques and processes that can be used to shape, fabricate, construct and assemble a high quality prototype, including techniques such as wastage, addition, deforming and reforming, as appropriate to the materials and/or components being used	**Wastage/Addition** • Cutting thermosetting and thermoforming plastics to the required shape or contour. • Tools and equipment to mark out, hold, cut, shape, drill, and form plastics • The pillar drill to drill holes to various diameters. • Jigs and formers to ensure accuracy as part of the process of drilling. • Pilot, clearance, tapping, countersunk and counterbored holes. **Deforming/Reforming** • Plastics joining can be permanent or temporary, by plastic welding and the use of nuts, bolts, washers, screws, rivets, hinges, catches. • Lathe to turn materials. • Milling machine to create a slot or face edge. • Lasers. • CAM machines. • Blow moulding. • Vacuum forming. • Press moulding.
	7. Appropriate surface treatments and finishes that can be applied for functional and aesthetic purposes	• Self-finishing nature of many thermosetting and thermoforming plastics. • Textured finishes of plastics.

In-depth knowledge and understanding		
	This section is for natural, synthetic, blended and mixed fibres, and woven, non-woven and knitted textiles. Learners are required to develop an in-depth knowledge and understanding of:	
	Content	Amplification
Natural, synthetic, blended and mixed fibres, and woven, non-woven and knitted textiles	**1.** The sources, origins, physical and working properties of the material categories or the components and systems, and their ecological and social footprint	• Construction methods, and how their advantages and disadvantages affect end use. • Weaving: plain, twill, satin, herringbone, pile. • Knitting: weft knit and a warp knit. • Bonding: sticking with adhesives; heating thermoplastic fibres; stitching a web of fibres. • Laminating. • Felting. • Fibres are the raw material of textiles and they can be classified according to their source. • The nature of staple and continuous filaments; textured yarns; novelty yarn (chenille) and these determine fabric weight, flexibility, handle and end use. • The properties of the main natural and manufactured fibres/fabrics including: strength, elasticity, absorbency, durability, insulation, flammability, water repellence, anti-static and resistance to acid, bleach, sunlight. • Blending and mixing fibres to improve the properties and uses of yarns and materials. • Blends: polyester and cotton, silk and viscose, hemp and cotton or silk. • Mixture: cotton and wool, lycra with wool cotton or nylon. • Bonding breathable waterproof membranes to outer fabrics for all-weather wear (Gore-Tex, Permatex). • Bonding foam to knitted or woven fabrics. • Bonding plastic to loosely woven cotton to simulate leather. • Quilting – polyester wadding between an outer and lining material. **Ecological and social footprint:** • The impact on our environment for example pollution from the processing of textiles, in parts of the world. • Changing society's view on waste, encourage recycling. • Living in a greener world. • Life-cycle analysis of a material or product.

Natural, synthetic, blended and mixed fibres, and woven, non-woven and knitted textiles	**2.** The way in which the selection of materials or components is influenced by a range of factors, such as functional, aesthetic, environmental, availability, cost, social, cultural and ethical	• A variety of finishing processes and why they are important for aesthetic and functional reasons.
		• Different methods of enhancing the appearance, prolonging and protecting life.
		• To enhance aesthetic quality:
		  ◦ Colouring, surface decoration, embossing, glazing, moiré effect, stiffening, increasing lustre (calendering, mercerising), brushing, stain resistance (Scotchguard, Teflon).
		• To enhance fabric life:
		  ◦ Flame retardant, moth proofing.
		• To improve functionality:
		  ◦ Shower proofing using PVA or PVC or wax; crease resistance using resin; waterproofing using silicones; shrink resistance using chlorine treatment; anti-static finish, coating with PVC, neoprene, silicone rubber, polyurethane; use of barrier membranes laminated to an outer or inner shell to make them breathable yet waterproof; windproof materials made by very close weave construction.
		• Responsibilities of designers and manufacturers who design using textiles with respect to:
		  ◦ the environment;
		  ◦ working conditions in third world countries, low labour costs and poverty;
		  ◦ exploitation of employees;
		  ◦ recyclability and waste;
		  ◦ biodiversity.

	3. The impact of forces and stresses on materials and objects and the ways in which materials can be reinforced and stiffened	• Textile materials and components behave differently when subjected to force or stress for example: a loaded rucksack, tents, uses in geotextiles, active sportswear, workwear, in normal daily wear. • The strength, durability and elasticity of textile materials will depend upon the fibre source and the construction method for the material or components. • Textile materials can be strengthened by laminating, bonding and quilting to improve functionality. • The strength of textile products will depend upon the combination of joining or fixing methods used.
	4. Stock forms, types and sizes in order to calculate and determine the quantity of materials or components required	• Textile materials come in standard widths 90cm, 115cm, 150cm, 200cm, 240cm. • Estimate material quantities and costs based on best use of materials. • Calculate costs and quantities for components.

Natural, synthetic, blended and mixed fibres, and woven, non-woven and knitted textiles	**5.** Alternative processes that can be used to manufacture products to different scales of production	• Products can be manufactured in quantity.
		  ◦ Different methods of manufacture: job production (custom-made or one–off); batch production; mass production and when each is appropriately used.
		  ◦ The scale of production depends on the quantity of products required.
		  ◦ How manufacturing systems are organised: line production; progressive bundle system; cell production.

	6. Specialist techniques and processes that can be used to shape, fabricate, construct and assemble a high quality prototype, including techniques such as wastage, addition, deforming and reforming, as appropriate to the materials and/or components being used	• The correct materials, hand tools and equipment for a range of practical tasks such as template production; stencil preparation; cutting out and assembly. • Change accessories when appropriate for special processes e.g. using a zipper foot for piping. • Industrial manufacturing processes for example, stitch, trim and neaten seams with the over locker. • CAD/CAM equipment for cutting templates accurately and continuously. • Pattern language and markers for lay plans. • Visual checks for pattern drop/match. • The importance of accuracy and working to a tolerance - correct use of seam tolerances in joining/trimming. • Correct use of thread-colour, type, shade, stitch length. • The appropriate choice of construction and decorative processes for fabric type and product end use. • The basic procedures for lay planning and use of pattern language. • Lengthwise / crosswise folds, cutting on the cross or bias, notches, grain lines, balance marks, tuck/pleat lines, dart markings, positions for pockets, buttons / holes, centre front / back lines, seam tolerance. • Different methods of transferring important marks onto material prior to product manufacture. • Tailor's chalk. • Hot notch marking in industry. • Different types of cutting tools and equipment used industry and know why they are used; • Cutting tools: ◦ straight knives, round or band knives, automated die cutters for products of constant shapes, computer controlled cutting machines and laser cutters. • Other equipment used for: lay planning and estimating material quantities, fabric spreading to include several plies.
	7. Appropriate surface treatments and finishes that can be applied for functional and aesthetic purposes	• Dyeing: piece, dip, random, tie and dye, batik. • Printing: silk screen, roller, discharge, block, burn out; stencilling; marbling; air brushing. • Painting: felt tip, dimensional, fabric paint, silk paints. • Transfers: image-maker, ink-jet transfer (CAM). • Embroidery: hand embroidery, machine embroidery, CAM. • Appliqué; beadwork.

2.2 Designing and making principles

Designing and making principles
Develop and apply core knowledge, understanding and skills

This section is designed to develop learners' knowledge, understanding and skills when designing and making prototypes. It describes the activities learners are required to undertake as part of the sustained design and make activity which forms the non-exam assessment (NEA) in this qualification.

Additionally, learners' knowledge and understanding of these designing and making principles will be assessed within the written examination.

Content	Amplification
1. Understand that all design and technological practice takes place within contexts which inform outcomes.	• Contexts are a starting point to inform possible outcomes, situations to create design briefs.
2. Identify and understand client and user needs through the collection of primary and secondary data.	• Identify the needs and wants of the end user. • Suggest possible design problems from the contexts. • Explore and investigate existing products, situations before deciding upon whether there is a real need for a product. • Explore and investigate existing products, situations to inform possible specification points for designing. • Primary research data: collecting data and using this to explore and aid further work. • Secondary research data: collecting existing data and using this to explore and aid further work.
3. Demonstrate an ability to write a design brief and specifications from their own and others' considerations of human needs, wants and interests.	• Write design briefs for specific needs, wants or interests. • Write specifications that are derived from their own investigations, the needs and wants of clients.
4. Investigate factors, such as environmental, social and economic challenges, in order to identify opportunities and constraints that influence the processes of designing and making.	• Designing should not take place in isolation but there are wider needs to be considered: • ergonomics • anthropometrics • environmental • social • economic
5. Explore and develop their ideas, testing, critically analysing and evaluating their work in order to inform and refine their design decisions thus achieving improved outcomes.	• The importance of testing and evaluating ideas. • Continuously reviewing and critically analysing work as it develops to improve the final design outcome. • Refine and modify design ideas based upon learners' own decisions and those of others.

<table>
<tr><td>6. Investigate and analyse the work of past and present professionals and companies in the area of design and technology in order to help inform their own ideas.</td><td>Investigate and analyse the work of past and present designers and companies, including:
Airbus
Apple
James Dyson
Philippe Starck
Matthew Williamson
Where appropriate, review and link the work of past and present designers and companies to inform, refine and modify their design ideas.</td></tr>
<tr><td>7. Use different design strategies, such as collaboration, user-centred design and systems thinking, to generate initial ideas and avoid design fixation.</td><td>Use of design strategies such as:
Collaboration – Discover, Define, Develop, Deliver.
User-centred design - Contexts, Requirements, Design solutions, Evaluate, Iteration.
Systems thinking.</td></tr>
<tr><td>8. Develop, communicate, record and justify design ideas, applying suitable techniques, for example: formal and informal 2D and 3D drawing; system and schematic diagrams; annotated sketches; exploded diagrams; models; presentations; written notes; working drawings; schedules; audio and visual recordings; mathematical modelling; computer-based tools.</td><td>Formal and informal 2D and 3D drawing.
System and schematic diagrams.
Annotated sketches.
Exploded diagrams.
Models.
Presentations.
Written notes.
Flow diagrams
Working drawings.
Schedules.
Audio and visual recordings.
Mathematical modelling.
Computer-based tools.</td></tr>
<tr><td>9. Design and develop at least one prototype that responds to needs and/or wants and is fit for purpose, demonstrating functionality, aesthetics, marketability and consideration of innovation.</td><td>Design and develop a prototype which :
Responds to needs and/or wants
Is fit for purpose,
Demonstrates functionality,</td></tr>
<tr><td>10. Make informed and reasoned decisions, respond to feedback about their own prototypes (and existing products and systems) to identify the potential for further development and suggest how modifications could be made.</td><td>Respond thoughtfully and make informed judgements when evaluating their own prototype.
Act on the views of others.
Make suggestions for improvements of their own prototype and how these modifications could be made.
Respond to feedback from others or clients and suggest improvements/modifications of their prototype.</td></tr>
</table>

Designing and making principles
Develop and apply in-depth knowledge, understanding and skills

Learners are required to develop and apply in-depth knowledge, understanding and skills in relation to at least one of the following:

- electronic systems, programmable components & mechanical devices
- papers & boards
- natural & manufactured timber
- ferrous & non-ferrous metals
- thermoforming & thermosetting polymers
- natural, synthetic, blended and mixed fibres; woven, non-woven and knitted textiles.

As for the core knowledge, understanding and skills described above, this section describes activities learners are required to undertake as part of the sustained design and make activity which forms the non-exam assessment (NEA) in this qualification. Learners are required to cover all of the content in these five areas, to ensure they are able to apply a broad knowledge and understanding of design and technology principles within the examined component.

Content	Amplification
1. Selecting and working with appropriate materials and components in order to produce a prototype.	• Select and work with appropriate materials or components that will realise their chosen prototype.

2. Using appropriate and accurate marking out methods including: measuring and use of reference points, lines and surfaces; use templates, jigs and/or patterns; work within tolerances; understand efficient cutting and how to minimise waste.	• When making prototypes, measure and mark out accurately
	• Consider how to minimise waste and make allowances for effective cutting methods.
	• Marking methods:
	  ◦ Measuring and use of reference points.
	  ◦ Lines and surfaces.
	  ◦ Use templates, jigs and/or patterns.
	  ◦ Work within tolerances.

3. Using specialist tools and equipment, appropriate to the materials or components used (including hand tools, machinery, digital design and manufacture), to create a specific outcome.	• When making prototypes learners should:
	  ◦ select and use specialist techniques, hand tools and machinery appropriate to the material being shaped or worked;
	  ◦ adhere to relevant Health and Safety regulations will need to applied appropriate to the environment they are working in.

4. Using specialist techniques and processes to shape, fabricate, construct and assemble a high quality prototype, including techniques such as wastage, addition, deforming and reforming, as appropriate to the materials and/or components being used.	• When making prototypes learners should use specialist techniques to:
	  ◦ Shape
	  ◦ Fabricate
	  ◦ Construct
	  ◦ Assemble
	• Include techniques such as wastage, addition, deforming and reforming, as appropriate to the materials and/or components being used.

5. Using appropriate surface treatments and finishes for functional and aesthetic purposes.	• Be aware and use appropriate surface finishing for different materials • The importance of finishing techniques to protect and enhance the aesthetics qualities of the material/s.

3 ASSESSMENT

3.1 Assessment objectives and weightings

Below are the assessment objectives for this specification. Learners must demonstrate their ability to:

AO1
Identify, investigate and outline design possibilities to address needs and wants

AO2
Design and make prototypes that are fit for purpose

AO3
Analyse and evaluate:

- design decision and outcomes including for prototypes made by themselves and others
- wider issues in design and technology

AO4
Demonstrate and apply knowledge and understanding of:

- technical principles
- designing and making principles

The table below shows the weighting of each assessment objective for each component and for the qualification as a whole.

	AO1	AO2	AO3	AO4	Total
Component 1	-	-	10%	40%	50%
Component 2	10%	30%	10%		50%
Overall weighting	**10%**	**30%**	**20%**	**40%**	**100%**

The table shows that AO3 is split between the two components. Component 1 assesses learners' ability to analyse and evaluate wider issues in design technology. Component 2 assesses learners' ability to analyse and evaluate design decisions and outcomes including for prototypes made by themselves and others.

3.2 Arrangements for non-exam assessment

The contextual challenge requires learners to demonstrate, at GCSE level, their knowledge and understanding of the following core designing and making principles, in the context of a sustained design and make activity. As detailed in Section 2.2, learners are required to:

- work within a context which will inform the outcome
- identify and understand client and user needs
- write a design brief and specifications
- identify opportunities and constraints that influence the processes of designing and making
- explore, develop, test, critically analyse and evaluate ideas
- investigate and analyse the work of others
- use different design strategies to generate initial ideas
- develop, communicate, record and justify design ideas
- design and develop at least one prototype* that is fit for purpose
- make informed and reasoned decisions to identify the potential for further development

In addition, when designing and making in relation to at least one material or component/ system(s) learners are required to:

- select and work with appropriate materials and components to produce a prototype
- use appropriate and accurate marking out methods; work within tolerances; understand efficient cutting and minimise waste
- use specialist tools and equipment, appropriate to the materials or components used, to create a specific outcome
- use specialist techniques and processes to shape, fabricate, construct and assemble a high quality prototype, as appropriate to the materials and/or components being used
- use appropriate surface treatments and finishes

* *In the context of this component, 'prototype' is used to describe all working solutions including products, models and systems.*

Assessment criteria for the contextual challenge

The assessment criteria for learners' contextual challenge (a sustained design and make task) are summarised in the table below and shown in detail in Appendix A.

Assessment Criteria		Marks	Assessment objective
(a)	Identifying and investigating design possibilities.	10	AO 1
(b)	Developing a design brief and specification.	10	
(c)	Generating and developing design ideas.	30	AO 2
(d)	Manufacturing a prototype.	30	
(e)	Analysing and evaluating design decisions and prototypes.	20	AO 3
	Total	100	

The design and make task is worth 50 per cent of the total marks available for this GCSE design and technology qualification. The design and make task is assessed by the centre and moderated by WJEC.

Contextual challenge titles

WJEC will publish the details of contextual challenges for GCSE Design and Technology on the WJEC secure website on 01 June in the calendar year preceding the year in which the qualification is to be awarded.

Learners will choose **one** contextual challenge from a range of **three** possible contextual challenges. The contextual challenges will be reviewed by WJEC every year.

Learners are required to complete **one** sustained design and make task, based on the contextual challenge they have chosen. Approximately 35 hours should be devoted to this task. Teachers are only required to monitor learners and because the design folio is iterative the learners should manage their time appropriately. In completing the design and make task, the learner will be required to produce the following evidence:

- a design brief developed in response to one of the contextual challenges set by WJEC
- a final prototype (or prototypes) based on that design brief, and
- additional evidence as necessary, including a design folio, to enable the assessment of the learner's attainment in each of the categories (a) to (e) in the table above.

Supervision

The design and make task must be appropriately supervised to ensure that assessors are able to confidently authenticate each learner's work.

The design and make task should be carried out in the normal design and technology classroom/workshop environment. Learners are allowed supervised access to resources that may include information gathered outside the 35 hours of assessment time, but their portfolios must be compiled within the school or college environment so that assessors can confidently authenticate the work.

Each learner must produce their final prototype or prototypes (though not necessarily their portfolio) under *'immediate guidance or supervision'.* This means the prototype(s) have to be produced either:

(i) with the simultaneous physical presence of the learner and the supervisor, or
(ii) remotely by means of simultaneous electronic communication.

In most cases supervision will be of the form described in (i), but in some circumstances, for example if the learner is carrying out a specialist process away from the centre, (ii) may be more appropriate.

The supervising teacher may give candidates limited guidance during the design and make task in order to clarify what is to be done and to ensure that safe working practices are followed.

Limited guidance refers to giving general advice to:

- support the learner only;
- ensure that the learner knows the requirements of the design and make task i.e. design folio of evidence, models, times etc;
- ensure that the learner's route through the contextual challenge will meet the requirements of the marking criteria and be of sufficient demand to potentially achieve the marks from the highest bands;
- enable the learner to feel comfortable in using the iterative process within the design and make task;
- ensure that all work being completed during the iterative journey is that of the learner. Where design work has been taken outside of the school environment, the teacher must monitor to validate that the work being produced is solely that of the learner;
- ensure safe storage and security of all work, to ensure plagiarism does not take place;
- advise on any health and safety issues.

Within limited guidance **teachers are not allowed to:**

- give the learner detailed advice and take the lead through the design and make process;
- specify the situation/task or brief,
- correct or modify the work of a learner;
- give specific direction to the learner to achieve higher marks;
- mark work and then return the work to the learner to improve;
- return the work to the learner once it has been submitted for marking and final marking has taken place ready for submitting to the board.

Where a teacher has had to give detailed guidance advice and support to the learner this **must be declared in writing by the centre** and marking of the work should be adjusted to reflect this support.

It is the responsibility of the centre to ensure the authenticity of all work presented for assessment. All learners are required to sign an authentication statement endorsing the originality of their work presented for assessment, and assessors must countersign that they have taken all reasonable steps to validate this. Authentication documentation must be completed by all learners, not just those selected for moderation.

All assessors who have marked learners' work must sign the declaration of authentication to confirm that the work is solely that of the learner concerned and has been conducted under the required conditions. Centres must ensure that the authentication documents are completed for each learner and made available to the moderator.

Instructions for non-exam assessments are provided by JCQ. These inform the operational practices required during non-exam assessment sessions. The head of the school or college is responsible for making sure that supervision and authentication is conducted in line with JCQ instructions and those laid out in this specification.

Assessment of the design and make task

The design and make task is assessed using the criteria shown in Appendix A.

The marks awarded will arise by matching the learner's performance in the design and make task to each of the five sets of criteria (targeting AO1, AO2 and AO3) and then deciding upon the extent to which the learner has demonstrated those criteria in their work.

Beginning at the lowest band, the assessor should consider the learner's work and establish whether it matches the descriptor for that band. If the descriptor at the lowest band is satisfied, the assessor should move up to the next band and repeat this process for each band until the descriptor accurately reflects the work.

If the work covers different aspects of different bands within the assessment criteria, a 'best fit' approach should be adopted to decide on the band and then careful analysis of the learner's work should be made to decide on the mark within the band. For example, if the work is judged to be mainly in band 2, but with a limited amount of band 3 content addressed, the work would be placed in band 2, but the mark awarded would be close to the top of band 2 as a result of the band 3 content.

Application of a 'best fit' approach is holistic and assessors should view the band as a whole when considering learners' work. It is not simply a case of adding up the number of bullet points within a band that the learner meets and awarding marks within the band on that basis. This is because the descriptors linked to each bullet point do not necessarily represent an equal amount of work or demand.

The assessment criteria are presented as a series of four bands, describing achievement from the lowest level worthy of a mark, to that which is worthy of full marks for the relevant set of criteria. In addition to applying the best-fit approach described above, assessors need to take into account the complexity of the candidate's design and make task and the method of manufacture.

It is important that learners are not discouraged from attempting challenging tasks and producing innovative solutions. Candidates should be appropriately rewarded for their achievements, however complex/simple their task. So a candidate who has attempted a complex task and has not been entirely successful could achieve a high overall mark for the NEA, when the complexity of the task is taken into account.

Assessors need to consider the quality achieved in the context of the demands of the prototype. Also, the means of manufacture needs to be taken into account: a component produced by 3D-printing, for example, may have an excellent finish, but will have been straightforward to achieve.

Outcomes do not need to be perfect to achieve full marks, but should reflect the standard expected at GCSE.

Internal moderation/standardisation

Where there is more than one assessor in a centre, the assessment of learners' design and make tasks must be standardised internally. This is to ensure that the final assessment accurately reflects a single agreed standard for all GCSE design and technology candidates entered for assessment by the centre.

Internal standardisation should involve all assessors independently marking sample pieces of work to identify any differences in marking standards. Such differences should be discussed collectively to arrive at an agreed common standard for the centre. Standardising material will be issued by WJEC to assist with this process.

Submission of marks

Centres are required to submit marks for the design and make task online at the beginning of May of the year in which the qualification is to be awarded. When marks have been submitted to WJEC, the online system will apply the sample formula based on the overall rank order for the entry and immediately identify the sample of learners whose work is selected for moderation.

Once learners' design and make tasks have been assessed by the centre and the marks have been submitted to WJEC, learners must not have access to their work for further development and the work must not be removed from the centre.

Moderation

A moderator appointed by WJEC will visit the centre during May in the year in which the qualification is awarded.

Moderators will provide detailed feedback to centres through a written report which will be made available on the day results are issued. Adjustments will be made when it is deemed that the centre's internal assessment does not conform to agreed common standards established by WJEC. If centres have concerns about the outcomes of moderation, they may access a range of post-results services as outlined on the WJEC website.

4 TECHNICAL INFORMATION

4.1 Making entries

This is a linear qualification in which all assessments must be taken at the end of the course. Assessment opportunities will be available in May/June each year, until the end of the life of this specification. Summer 2019 will be the first assessment opportunity.

Where candidates wish to re-sit the qualification, all components must be re-taken.

The current edition of our *Entry Procedures and Coding Information* gives up-to-date entry procedures.

4.2 Grading, awarding and reporting

GCSE qualifications are reported on a nine point scale from 1 to 9, where 9 is the highest grade. Results not attaining the minimum standard for the award will be reported as U (unclassified).

APPENDIX A

Non-exam assessment marking criteria

The assessment criteria for learners' contextual challenge (a design and make task) are summarised in the table below and shown in detail in the following pages. A definition of key terms used within each assessment objective precedes the relevant assessment criteria.

	Assessment Criteria	Marks	Assessment objective
(a)	Identifying and investigating design possibilities.	10	AO 1
(b)	Developing a design brief and specification.	10	
(c)	Generating and developing design ideas.	30	AO 2
(d)	Manufacturing a prototype.	30	
(e)	Analysing and evaluating design decisions and prototypes.	20	AO 3
	Total	100	

AO1	Identify, investigate and outline design possibilities to address needs and wants
Definitions used in AO1	
Identify	looking at areas and opportunities in which designs can take place
Investigate	pursuing ideas and gathering information relating to a context
	identify and investigate are interdependent - the processes work together and take place in no particular order
Outline	to produce a design brief and specification to inform AO2

<table>
<tr><th>(a) Identifying and investigating design possibilities [AO1]
The candidate has:</th><th>Band</th></tr>
<tr><td>9 – 10 marks
undertaken a comprehensive and effective identification of opportunities for the development of designs within the prescribed context.
undertaken comprehensive, relevant research and investigation, clearly linked to the context and, where appropriate, the work of past/present professionals and companies.
undertaken an effective analysis of information, reflecting the needs, wants and values of clients or potential users.
identified a range of problems/opportunities to clearly inform the development of possible design briefs.</td><td>4</td></tr>
<tr><td>6 – 8 marks
undertaken a generally effective identification of opportunities for the development of designs within the prescribed context.
undertaken relevant research and investigation, linked to the context and, where appropriate, the work of past/present professionals and companies.
undertaken a mostly effective analysis of information, reflecting the needs, wants and values of potential users.
identified a range of problems/opportunities to inform the development of possible design briefs.</td><td>3</td></tr>
<tr><td>3 – 5 marks
identified some opportunities for the development of designs within the prescribed context.
undertaken research and investigation, generally linked to the context and, where appropriate, the work of past/present professionals and companies.
undertaken a partially effective analysis of information, though the needs, wants and values of potential users may not have not been fully considered.
identified some problems/opportunities which partially inform the development of possible design briefs.</td><td>2</td></tr>
<tr><td>1 – 2 marks
identified one opportunity for the possible development of designs within the prescribed context.
undertaken little research and investigation, which is only partially linked to the context.
undertaken a superficial analysis of information, with little or no consideration of the needs, wants and values of potential users.
identified few problems/opportunities and developed a design brief with little reference to their investigations.</td><td>1</td></tr>
<tr><td colspan="2">0 marks
produced no work that is worthy of a mark.</td></tr>
</table>

<table>
<tr><th>(b) Developing a design brief and specification [AO1]
The candidate has:</th><th>Band</th></tr>
<tr><td>9 – 10 marks
• fully considered a range of problems/opportunities before deciding upon a final design brief.
• demonstrated a very good understanding of the task ahead and the requirements which have to be met, to satisfy fully the needs, wants and interests of potential users.
• written a design brief, relevant to the context, based upon a thorough analysis of their research and investigation.
• written a detailed, relevant specification, including a range of objective and measurable criteria, to direct and inform the design and manufacture of a prototype.</td><td>4</td></tr>
<tr><td>6 – 8 marks
• considered a range of problems/opportunities before deciding upon a final design brief.
• demonstrated a good understanding of the task ahead and most of the requirements which have to be met, to satisfy most of the needs, wants and interests of potential users.
• written a design brief, relevant to the context, based upon a general analysis of their research and investigation.
• written a relevant specification, including a range of objective and measurable criteria, to inform the design and manufacture of a prototype.</td><td>3</td></tr>
<tr><td>3 – 5 marks
• considered some problems/opportunities before deciding on a final design brief.
• demonstrated a general understanding of the task ahead and one or two requirements have been identified to satisfy some of the needs, wants and interests of potential users.
• written a design brief, based upon some aspects of the analysis of their research and investigation.
• written a specification, including the key points, to partially inform the design and manufacture of a prototype.</td><td>2</td></tr>
<tr><td>1 – 2 marks
• focussed on a single opportunity to produce a design brief.
• demonstrated a limited understanding of the task ahead, with little or no consideration of the needs, wants and interests of potential users.
• written a design brief based upon simple analysis of their research and investigation.
• produced a small range of partially appropriate specification points.</td><td>1</td></tr>
<tr><td colspan="2">0 marks
• produced no work that is worthy of a mark.</td></tr>
</table>

AO2	**Design and make prototypes that are fit for purpose**
Definitions used in AO2	
Design	the generation and development of ideas that can be presented to a third party, and can be evaluated and tested (however, the actual analysis and evaluation forms part of AO3).
Prototype	an appropriate working solution to a need or want that is sufficiently developed to be tested and evaluated (for example, full sized products, scaled working models or functioning systems).
Fit for purpose (prototype)	in addition to being a working solution, addressing the needs/wants of the intended user.
	making skills can be assessed through the designing and making of the prototype(s), as well as the nature and quality of the final prototype.

(c) Generating and developing design ideas [AO2] *The candidate has:*	**Band**
24 – 30 marks • considered a range of design strategies, techniques and approaches and applied an iterative design process to generate and communicate a range of excellent initial ideas. • fully identified and considered social, moral and economic factors which are relevant to the context and potential user(s). • clear, effective and detailed use of testing to evolve ideas and to refine their design decisions. • developed an excellent proposal, including comprehensive and relevant details of materials, dimensions, finishes and production techniques, which clearly address all requirements of the design brief and specification. • demonstrated sophisticated use of skills/techniques to clearly communicate ideas and proposals to a third party.	**4**
16 – 23 marks • considered a range of design strategies, techniques and approaches and applied an iterative design process to generate and communicate a range of good initial ideas. • identified and considered social, moral and economic factors which are generally relevant to the context and potential user(s). • clear and generally effective use of testing to evolve ideas and to refine their design decisions. • developed a good proposal, including relevant details of materials, dimensions, finishes and production techniques, which address most requirements of the design brief and specification. • demonstrated good use of skills/techniques to communicate ideas and proposals to a third party.	**3**

8 – 15 marks • considered some design strategies and techniques and applied an iterative design process to generate and communicate a range of basic initial ideas. • identified social, moral and/or economic factors with some attempt to relate these to the context and potential user(s). • made some use of testing to evolve ideas and to refine their design decisions. • developed a basic proposal, including details of materials, dimensions, finishes and/or production techniques, which address the main requirements of the design brief and specification. • demonstrated satisfactory use of skills/techniques to communicate ideas and proposals to a third party.	**2**
1 – 7 marks • generated and communicated a limited range of undeveloped initial ideas. • identified aspects of social, moral or economic factors, though these are not closely related to the context and or potential user(s). • made little or no use of testing to evolve ideas. • developed a limited proposal, with superficial details of materials, dimensions, finishes and/or production techniques which addresses few requirements of the design brief and/or specification. • demonstrated limited ability to communicate their idea(s) to a third party.	**1**
0 marks • produced no work that is worthy of a mark.	

(d) Manufacturing a prototype [AO2] *The candidate has:*	Band
24 – 30 marks • clearly communicated comprehensive and relevant details of a logical sequence and achievable timeline for the stages of production and testing of their final prototype. • worked with appropriate materials and components to complete all aspects of the manufacture of their prototype to a defined schedule. • used appropriate making skills and processes to produce a high quality functioning prototype that fully meets the requirements of the design specification and is fit for purpose. • an excellent understanding of the working properties and performance characteristics of the specified materials and, where appropriate, demonstrated consideration of surface treatments/finishes. • selected and safely used specialist tools, appropriate techniques, processes, equipment and machinery with excellent accuracy and precision to enable the prototype to perform as intended and fully meet the user's requirements.	**4**
16 – 23 marks • communicated details of a logical sequence and achievable timeline for the stages of production and testing of their final prototype. • worked with appropriate materials and components to complete most aspects of the manufacture their prototype, generally to a defined schedule. • used appropriate making skills and processes to produce a good quality functioning prototype that meets the requirements of the design specification and is fit for purpose. • a good understanding of the working properties and performance characteristics of the specified materials and, where appropriate, demonstrated consideration of surface treatments/finishes. • selected and safely used specialist tools, appropriate techniques, processes, equipment and machinery with good accuracy and precision to enable the prototype to perform as intended and generally meet the user's requirements.	**3**
8 – 15 marks • communicated details of a sequence for manufacture and testing of their final prototype. • worked with materials and components to partly complete the manufacture of their prototype, generally to a defined schedule. • used making skills and processes to produce a functioning prototype that partially meets the requirements of the design specification and is generally fit for purpose. • an understanding of the main working properties and performance characteristics of the specified materials and, where appropriate, demonstrated basic consideration of surface treatments/finishes. • selected and safely used specialist tools, techniques, processes, equipment and machinery with a fair degree of accuracy and precision, the prototype only just performs as intended and meets some aspects of the user's requirements.	**2**

1 – 7 marks • communicated superficial or no details of a sequence for manufacture and/or testing of their final prototype. • worked with materials and components to partly complete the manufacture of their prototype. • implemented making skills and processes to produce a partially functioning prototype, some aspects of which meet elements of the design specification. • a limited understanding of the working properties and/or performance characteristics of the specified materials. • selected and safely used specialist tools, techniques, processes, equipment and machinery with a limited degree of accuracy, the prototype partially or is unable to fully perform as intended, though meets few aspects of the needs, wants and values of the user.	**1**
0 marks • produced no work that is worthy of a mark.	

AO3	**Analyse and evaluate** • **design decisions and outcomes, including for prototypes made by themselves and others** • **wider issues in design and technology**
Definitions used in AO3	
Analyse	Deconstructing information and/or issues to find connections and provide logical chain(s) of reasoning.
Evaluate	Appraising and/or making judgements with respect to information and/or issues.
	Analysis and evaluation should draw on underpinning knowledge and understanding.

(e) Analysing and evaluating design decisions and prototypes **[AO3]** *The candidate has:*	**Band**
16 – 20 marks • undertaken a critical, objective analysis, evaluation and testing of their ideas and decisions whilst applying iterative design processes. • undertaken a critical and objective evaluation and testing of their final prototype, taking into account the views of potential users. • responded to feedback and clearly identified the potential for further development of their prototype, with detailed suggestions for how modifications could be made.	**4**
11 – 15 marks • undertaken an objective analysis, evaluation and testing of their ideas and decisions whilst applying iterative design processes. • undertaken an objective analysis, evaluation and testing of the final prototype, with some consideration of the views of potential users. • responded to feedback and identified the potential for further development of their prototype, suggesting how modifications could be made. • responded to feedback and identified the potential for further development of their prototype, with suggestions of how modifications could be made.	**3**
6 – 10 marks • undertaken a basic analysis, evaluation and/or testing of their ideas and decisions whilst applying iterative design processes. • undertaken a basic analysis, evaluation and/or testing of their final prototype, with partial consideration of the views of potential users. • identified the potential for some further development of their prototype, including suggestions of how modifications could be made.	**2**
1 – 5 marks • produced a superficial evaluation of their ideas and decisions. • produced a superficial evaluation of their final prototype. • partially identified how their prototype could be modified.	**1**
0 marks • produced no work that is worthy of a mark.	

APPENDIX B

Links to mathematics and science

Through their work in design and technology learners are required to apply relevant knowledge, skills and understanding from key stage 3 and key stage 4 courses in the sciences and mathematics.

They should use the metric and International System of Units (SI) system but also be aware that some materials and components retain the use of imperial units.

Through the assessment of their knowledge and understanding of technical principles and designing and making skills learners will be required to demonstrate an understanding of the mathematical and scientific requirements shown in the following tables. The examples in the tables below are illustrative of how the mathematical skills and scientific knowledge and skills identified could be applied in design and technology.

Links to mathematics

Learners must be able to apply the following mathematical skills.

Ref	Mathematical skills requirements	Examples of D&T applications	Examples of specification content
1	*Arithmetic and numerical computation*		
a	Recognise and use expressions in decimal and standard form.	Calculation of quantities of materials, costs and sizes.	NEA (assessment criteria **(c)**) – details of dimensions. 2.1 in-depth**, 4.** Stock forms, types and sizes in order to calculate and determine the quantity of materials or components required.
b	Use ratios, fractions and percentages.	Scaling drawings, analysing responses to user questionnaires.	NEA (assessment criteria **(a)**) – analysis of information. 2.1 core, **7.** The functions of mechanical devices, to produce different sorts of movement, changing the magnitude and direction of forces.
c	Calculate surface area and volume.	Determining quantities of materials.	NEA (assessment criteria **(d)**) – manufacturing a prototype. 2.1 in-depth**, 4.** Stock forms, types and sizes in order to calculate and determine the quantity of materials or components required.

Ref	Mathematical skills requirements	Examples of D&T applications	Examples of specification content
2	*Handling data*		
a	Presentation of data, diagrams, bar charts and histograms.	Construct and interpret frequency tables; present information on design decisions.	NEA (assessment criteria **(c)**) – communicating ideas and proposals to a third party.
3	*Graphs*		
a	Plot, draw and interpret appropriate graphs.	Analysis and presentation of performance data and client survey responses.	NEA (assessment criteria **(a)**) – analysis of information.
b	Translate information between graphical and numeric form.	Extracting information from technical specifications.	NEA (assessment criteria **(a)**) – analysis of information.
4	*Geometry and trigonometry*		
a	Use angular measures in degrees.	Measurement and marking out, creating tessellated patterns.	NEA (assessment criteria **(d)**) **–** manufacturing a prototype.
b	Visualise and represent 2D and 3D forms including two dimensional representations of 3D objects.	Graphic presentation of design ideas and communicating intentions to others.	NEA (assessment criteria **(c)**) **–** communicating ideas and proposals to a third party.
c	Calculate areas of triangles and rectangles, surface areas and volumes of cubes.	Determining the quantity of materials required.	NEA (assessment criteria **(d)**) – manufacturing a prototype. 2.1 in-depth**, 4.** Stock forms, types and sizes in order to calculate and determine the quantity of materials or components required.

Links to science

Learners must be able to apply the following scientific knowledge and skills.

Ref	Scientific knowledge and skills requirements	Examples of D&T application	Examples of specification content
1	*Use scientific vocabulary, terminology and definitions*		
a	Quantities, units and symbols.	Appropriate use of scientific terms when developing a design brief and specifications.	NEA (assessment criteria **(b)**) – developing a design brief and specification.
b	SI units (e.g. kg, g, mg; km, m, mm; kJ, J), prefixes and powers of ten for orders of magnitude (e.g. tera, giga, mega, kilo, centi, milli, micro and nano).	Calculation of quantities, measurement of materials and selection of components.	NEA (assessment criteria **(d)**) – manufacturing a prototype.
c	Metals and non-metals and the differences between them, on the basis of their characteristic physical and chemical properties.	Classification of the types and properties of a range of materials.	technical principles – core knowledge and understanding – materials (sections 8 to 12).
2	*Life cycle assessment and recycling*		
a	The basic principles in carrying out a life- cycle assessment of a material or product.	Selection of materials and components based on ethical factors, taking into consideration the ecological and social footprint of materials.	technical principles – in-depth knowledge and understanding (section 2 in all material areas).

Ref	Scientific knowledge and skills requirements	Examples of D&T application	Examples of specification content
3	*Using materials*		
a	The conditions which cause corrosion and the process of corrosion and oxidisation.	Understanding of properties of materials and how they need to be protected from corrosion through surface treatments and finishes. Appreciate how oxidisation can be used when dyeing materials.	technical principles – core knowledge and understanding – materials (section 10 ferrous and non-ferrous metals).
b	The composition of some important alloys in relation to their properties and uses.	Selecting appropriate materials.	technical principles – core knowledge and understanding – materials (section 10 ferrous and non-ferrous metals).
c	The physical properties of [materials], how the properties of materials are selected related to their uses.	Knowledge of properties of materials to be applied when designing and making.	NEA (assessment criteria **(d)**) – manufacturing a prototype.
d	The main energy sources available for use on Earth (including fossil fuels, nuclear fuel, bio-fuel, wind, hydro-electricity, the tides and the Sun), the ways in which they are used and the distinction between renewable and non-renewable sources.	Understanding of how to choose appropriate energy sources.	technical principles – core knowledge and understanding – D&T and our world – (section 3 how energy is generated and stored).
e	The action of forces and how levers and gears transmit and transform the effects of forces.	Knowledge of the function of mechanical devices to produce different sorts of movement, changing the magnitude and direction of forces.	technical principles – core knowledge and understanding – mechanical components and devices (section 7 the functions of mechanical devices).