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Preface

This is a brand new book that provides comprehensive yet concise coverage of all the topics covered in the new AQA 8552 Design and Technology (9-1) specification, written and presented in a way that is accessible to teenagers and easy to teach from. It can be used both as a course text and as a revision guide for students nearing the end of their course.

It is divided into 12 sections covering every element of the specification. Sections 5A to 5F of the textbook cover each of the specialist technical areas. These sections would complement practical classroom experience.

Each chapter contains exercises and questions, some new and some from past examination papers. Answers to all of these are available to teachers only in a Teacher's Supplement which can be ordered from our website **www.pgonline.co.uk**.

Approval message from AQA

This textbook has been approved by AQA for use with our qualification. This means that we have checked that it broadly covers the specification and we are satisfied with the overall quality. Full details of our approval process can be found on our website.

We approve textbooks because we know how important it is for teachers and students to have the right resources to support their teaching and learning. However, the publisher is ultimately responsible for the editorial control and quality of this book.

Please note that when teaching the GCSE Design and Technology course, you must refer to AQA's specification as your definitive source of information. While this book has been written to match the specification, it cannot provide complete coverage of every aspect of the course.

A wide range of other useful resources can be found on the relevant subject pages of our website: www.aqa.org.uk.

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Core technical principles

Specialist technical principles

Designing and making principles

Section 1

New and emerging technologies

In this section:

1

Virtual marketing and retail

Virtual marketing and **virtual retail** includes the use of websites, social media, email and digital marketing to reach a wider audience and potential client base in order to promote a product, service or idea.

Virtual campaigns using social media to spread the word have become a very popular way to launch products. Facebook and YouTube have become huge platforms to promote business and enterprise ideas. Other social media platforms include the professional network LinkedIn where business-minded people can share their ideas and services. Additionally, blogs and vlogs are targeted to appeal to new audiences, and small fortunes are being amassed by enterprising people who have a large online following.

A more subtle form of virtual marketing is **search engine optimisation**. Companies make efforts to boost their website higher up internet search results than their competition. The goal is also to make their website appear on the first page of search results for as many relevant keyword requests as possible. Virtual marketing also includes paid-for advertisements that appear beside search results.

Cooperatives

A **cooperative** is an enterprise that is commonly owned and run by its members who may comprise its workforce or its customers. Cooperatives are formed to enable a group of people with the same business interests to have greater protection and a stronger democratic voice. Cooperatives can be a cost-effective way to sell goods and services and are frequently based around a local community. They are set up to protect the rights of its members and ensure fair and just terms and conditions apply to all members.

Q7 How might the staff-owners of a worker-cooperative be motivated differently to staff of a non-cooperative organisation?

Fairtrade

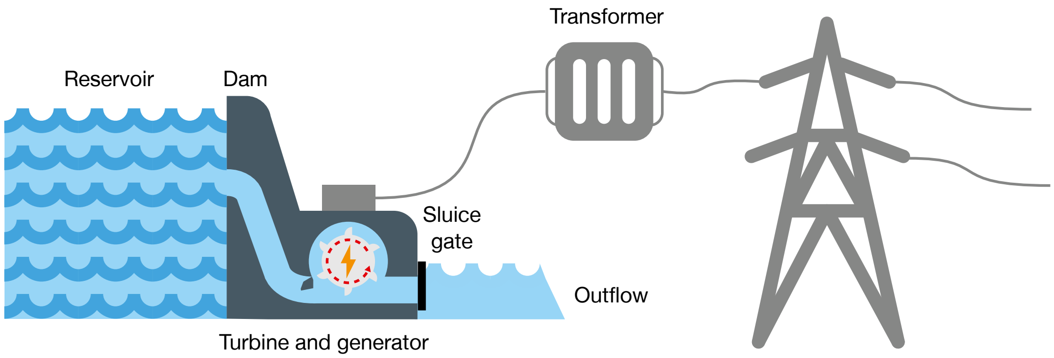
Fairtrade is about better prices, decent working conditions and fair terms of trade for farmers and workers in less economically developed countries.

Fairtrade supports the development of thriving farming and worker communities that have more control over their futures and protecting the environment in which they live and work.

It is an alternative approach that is based on partnership; one between those who grow food and those who consume it. When you buy products with the Fairtrade Mark, it means that the Fairtrade ingredients in the product have been produced by small-scale farmer organisations or plantations that meet Fairtrade social, economic and environmental standards. The standards include protection of workers' rights and the environment, payment of the Fairtrade Minimum Price and an additional Fairtrade Premium to invest in business or community projects. Around 2 million farmers and workers in 71 countries benefit from having Fairtrade certification for their products.

FAIRTRADE FOUNDATION

Power generation is more efficient during periods of heavy rainfall. At other times, water is pumped back up to the top of the reservoir when the demand for electricity is low. The flow of water through the turbine is easily controlled, making it simple to alter the power being produced depending on the demand at different times of the day.



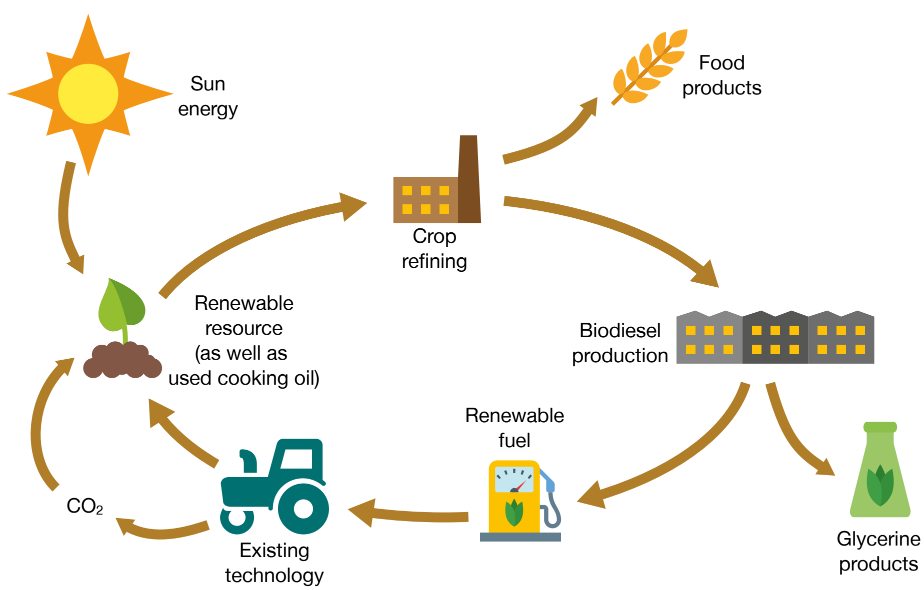
Q7 What might be the impact on the natural environment and wildlife of constructing a dam at the end of a valley and flooding the valley to create a reservoir for a hydroelectric power station?

Q8 List as many positive factors for hydroelectric power as you can.

2

Biofuel

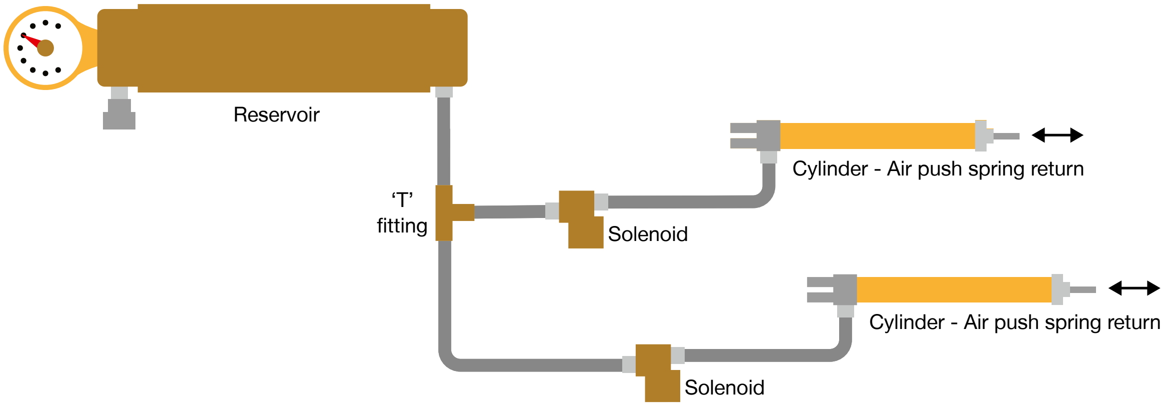
The production of **biofuel** is becoming a viable way of producing energy for our transportation and heating needs. Oil- and starch-producing crops are grown, harvested and refined into a number of products, including biodiesel. The process is commonly known as **biomass** energy production. The term biomass can include other solid biofuels such as wood chips and farm waste.



In 2022, biomass accounted for around 7% of the UK's electricity supply, and 6% of the fuel for the UK's transportation system came from biodiesel, according to the Department of Transport. A growing number of companies and private users are recycling spent cooking oil, (a waste product from the catering industry) and converting it into biodiesel by refining it independently.

Pneumatics

Another form of compression is used to store gas or air under pressure. This area of mechanical power is known as **pneumatics**, where movement is controlled by using a system of valves, actuators, pistons and other dedicated controllers. Pneumatic systems are commonplace for controlling production lines in the manufacturing industry. They are accurate, efficient and relatively low maintenance.



Hydraulics

The gas or air in a pneumatic system can be swapped for a liquid, most commonly oil. This type of movement control is known as **hydraulics** and is commonly used in car braking systems and lifting gear like forklift trucks and tractors. Hydraulic systems can be extremely powerful and are also used in many industrial applications.

Both hydraulic and pneumatic systems need **compression** in order for the systems to operate. This is usually delivered through a type of pump called a compressor. These come in many different shapes and sizes, depending on the task and the amount of pressure required.

Most compressors have a storage tank where the air or liquid is held under pressure ready to be used. When the pressure in the tank falls below a preset minimum, the compressor will automatically turn on and build the pressure back up to the preset maximum level. The pressure is measured in **bar**.

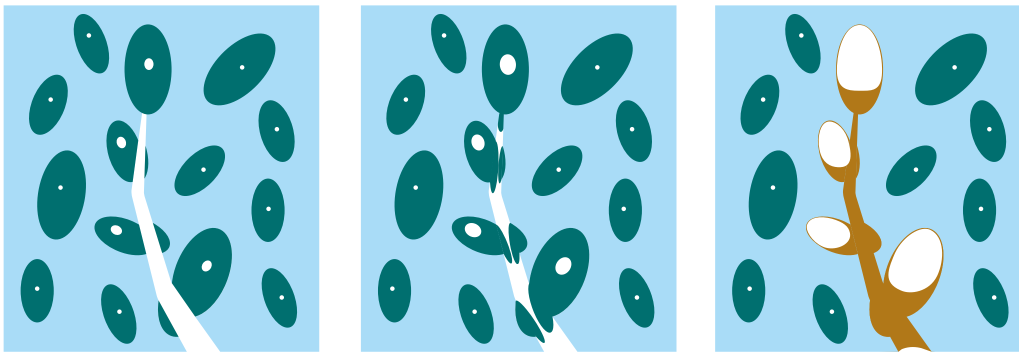
Q4 How does a pump build up pressure in pneumatic and hydraulic systems?

Q5 Define the difference between a pneumatic and a hydraulic system.

Q6 Find out what pressure in bar mains water is usually supplied at in your area.

Self-healing materials

Self-healing polymers and bio-concrete are two examples of materials that can respond to stress fractures and repair themselves. Self-healing polymers contain microencapsulated resin-based adhesives that are released and activated when stress fractures are caused. Resin fills the crack and hardens, leaving a small bubble behind instead of a long fracture. Bio-concrete uses a special bacteria mixture that can fill fractures with calcium carbonate (limestone) when water seeps in, creating a solid repair.



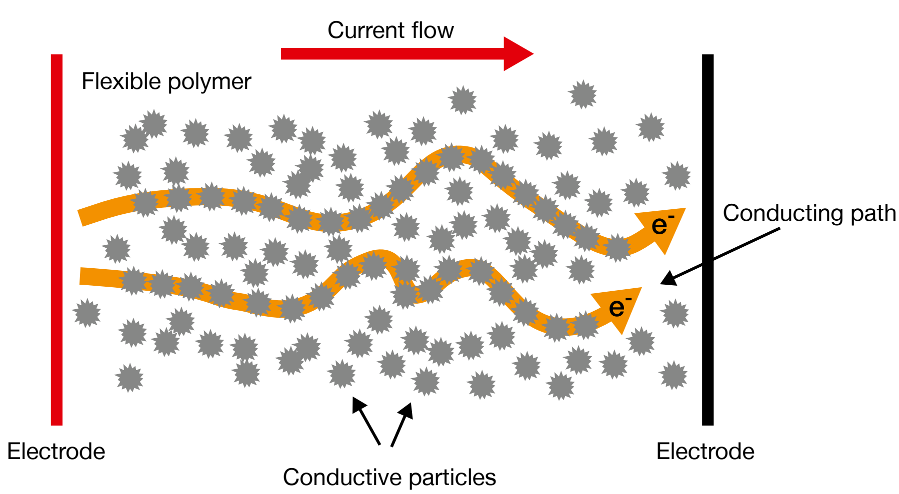
Microcapsules ruptured by fracture | Polymer resin is released into fracture | Resin hardens and heals damage

Q6 Discuss the potential benefits of using self-healing concrete in civil engineering projects such as bridges, tunnels and roads.

2

Quantum Tunnelling Composite

This smart material has the ability to be either a **conductor** or an **insulator**. QTC® varies its electrical resistance depending on the amount of pressure or stress applied to it. The more pressure applied, the less resistance it has. Therefore, in a lighting application the harder you press, the brighter the lamp would shine. It works because billions of conductive nanoparticles are held in a polymer without actually touching each other. When no pressure is applied the material is an insulator, but when pressure is applied, the conductive particles move closer together and it becomes a conductor.



A number of applications have been developed for QTC®, including variable-speed controls for power tools and home appliances, touch-sensitive pads for interaction with computers and mobile technology, flexible keyboards and wearable technology.

Exercises

1. Describe how electricity is generated from fossil fuels. [2]

2. (a) Name **three** different types of renewable energy. [3]

   (b) Describe the process of generating energy using **one** of the renewable energy sources you have named in your answer to part (a). [2]

3. Evaluate the points for and against nuclear power. [6]

4. (a) State the typical voltage provided by each cell in a 3 volt battery. [1]

   (b) A PP3 battery as shown below produces 9V.

   An electrical product requires an 18V supply.

   Calculate how many cells are used if two PP3 batteries are used. [3]

   (c) Explain **one** advantage for the user of using rechargeable batteries. [2]

5. Explain **two** advantages of using metal foams in military vehicles. [4]

6. Describe how Nitinol, an SMA, could be used to control the fingers and thumb on a robotic hand. [2]

7. The picture below shows a baby feeding spoon.

   The polymer contains a thermochromic pigment.

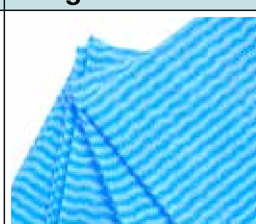
   Explain **one** reason for using a thermochromic pigment in the polymer for the baby feeding spoon. [2]

8. Explain **two** advantages of making a hockey stick out of carbon fibre rather than GRP. [2]

Non-woven textiles

Non-woven fabrics are made directly from fibres without being spun into yarns. The most commonly available non-woven fabrics are bonded fabrics made from a web of fibres held together with heat or adhesive. Common uses of non-woven fabrics include disposable products such as garments worn by surgeons and crime scene investigators, dishcloths and interfacings. Non-woven fabrics can be given special treatments such as flame resistance to make head rest covers on trains and aircraft.

Felting is a mechanical process which has traditionally been done by hand, but is now mainly machine produced. It involves matting together wool or synthetic fibres using a combination of heat, pressure, moisture and movement to mesh the fibres together in a random way. Felt can be formed into shapes when wet (see drape formed hats in Chapter 37), but it does not have any elasticity and will not drape well when dry. It is not strong and can pull apart under tension, but unlike woven fabric, will not fray when cut.

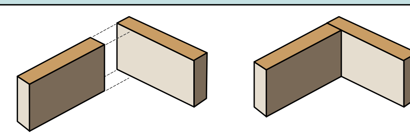
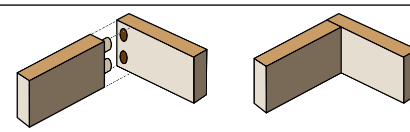
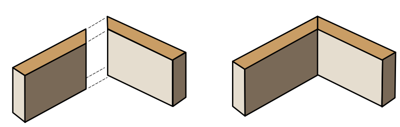
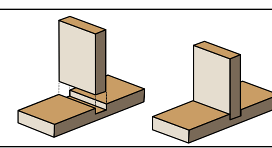
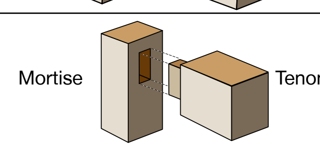
Name	Appearance	Image	Characteristics	Example uses
Bonded fabric	Random laid fibres are visible in the fabric, it can have small holes or a textured surface		Fabrics lack strength, they have no grain so can be cut in any direction and do not fray	Disposable products such as protective clothing worn for hygiene purposes, tea bags, dish cloths and dusters
Felted fabric	Matted fibres randomly interspersed, wide range of colours and thicknesses		Can be formed with moisture and heat; once dry it has no elasticity or drape, and can pull apart easily. Woollen varieties can be expensive	Hats, handicraft, pads under furniture to prevent scratching, soundproofing and insulation

Q5 What might happen to woollen felted products if they are washed in hot water?

'New Sling' - Steam bent seat by David Trubridge

Wood joints

One of the most effective ways to join two or more pieces of wood is with a wood joint. Wood joints can be used to fabricate carcase constructions e.g. a drawer or bookshelf, and frame constructions e.g. tables, chairs and picture frames. Joints need to be made precisely and time should be taken to mark out accurately and ensure that any cuts are made on the waste side of the marked out lines. Joints are best pared down with a chisel if they do not fit first time. It is preferable to have wood joints that are a tight fit rather than ones which are too loose and require filling, as this can weaken them.

Name	Characteristics	Image
Butt joint	The most basic joint, not very strong due to little surface area for the adhesive and no mechanical advantage. Pins or nails often used	
Dowelled joint	Similar to the butt joint but with wooden dowels that add strength and assist rigidity. Dowels are glued in for extra strength	
Mitre joint	More attractive than the butt joint and used for picture frames and surrounds. Weak due to lack of surface area, metal splines can be used to help strengthen them	
Housing joint	A stronger joint that has larger surface area for glueing and the physical advantage of the wood being supported by three sides	
Mortise and tenon joint	A strong joint used in table and chair construction. Very large surface area for glue and good physical advantage created by the tenon	

Q11 Which joint from this selection do you think would best suit the following tasks?

(a) A shelf

(b) Architrave around a door frame

(c) A raised vegetable bed made from railway sleepers

Chapter 38 – Commercial manufacturing, surface treatments and finishes

Objectives

- Know and understand how textile based materials are selected and processed for commercial products
- Understand why aids are used to judge quality and accuracy before and during processing
- Understand how surface treatments and finishes affect the functional and aesthetic properties of textile products

Textiles for commercial products

Commercial textile production has developed significantly over the last 50 years owing to new materials being invented as well as new industrial manufacturing methods and higher levels of computer driven automation. Both 'technology push', in the form of new materials and 'market pull' with demand for greater performance of fabrics, have contributed to a huge and expanding industry.

The introduction of stretch fabrics has transformed aerodynamics, especially seen in cycling and swimming, enabling items of clothing to fit tightly thus reducing drag yet allowing for freedom of movement by the wearer. **Wicking fabrics** have also been of huge benefit to athletes and outdoor adventurers by allowing perspiration to evaporate quickly, keeping the wearer dry.

Sportswear and outdoor apparel have gone through more changes than many other areas of textiles over the last few decades owing to constant developments in new technologies, giving a greater range of physical and working properties to use. These fabrics can also take advantage of **microencapsulation**. (See Chapter 10 for more detail.)

Q1 How have developments in commercial textiles helped to improve comfort and safety in motorsport apparel?

Commercial developments in the area of home and business furnishings have led to a greater range of choice through colours, styles and levels of quality. Furnishings cover a multitude of interior, and increasingly, exterior quality textiles, including carpets, rugs, upholstery fabrics, curtains, cushions and many more. These products all form part of our living and working spaces and are chosen for many different reasons. Aesthetics are very important to most people, but the physical and working properties may well be of equal or greater concern to a customer.

Section 5 Exercises

Exercises in this section are generic so that answers may be given in context that apply appropriate techniques, knowledge and understanding from any of the material areas.

1. Choose **one** of the materials in the table below.

Materials				
Solid white board	**Ash**	**Low carbon steel**	**Acrylic**	**Cotton**

Name **one** surface finish or treatment that can be applied to the material to enhance the functional or mechanical properties.

Use notes and/or sketches to explain how the surface finish or treatment can be changed to improve or enhance its properties. [5]

Name of material: ______________________________

Surface finish or treatment: ______________________________

2. Describe **two** ways that materials can be shaped or formed.
Give examples in your answers. [4]

3. Five materials are listed in the table below. Choose **one** material:

Materials				
Corrugated card	**Plywood**	**Low carbon steel**	**Polyvinyl chloride (PVC)**	**Wool yarn**

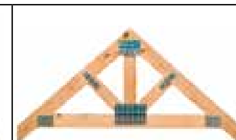
(a) State **one** raw primary source material of your chosen material. [1]

(b) Give **one** stock form in which the material is likely to be available. [1]

(c) Describe the manufacturing process(es) used to turn the raw primary source material into a stock form. You may include sketches in your answer. [3]

(d) Describe **two** ways that one of the materials can be modified. [4]

4. Choose **one** product or component from the table below and describe **two** features that make it suitable for mass production. [4]

				
Aluminium drink can	**PET water bottle**	**Foil lined board**	**Cotton skirt**	**Pine roof truss**

The Aquatics Centre at the Queen Elizabeth Olympic Park, designed by Zaha Hadid Architects

Yinka Ilori 1987

Yinka draws on his British-Nigerian heritage to create bold and visually distinctive designs. His brave use of colour runs through his architecture, furniture design and interiors. He has transformed basketball courts, skate-board parks, pedestrian crossings, laundrettes as well as a host of everyday spaces into fresh and vibrant environments with the use of bold colour.

Charles Rennie Mackintosh 1868–1928

Mackintosh was a Scottish, Glasgow-based designer, architect and artist who played a formative role in the **Art Nouveau** movement. He was known for his use of light and shadow, along with modernist geometric lines interlaced with natural forms and a hint of Asian and Japanese influence.

Elsie Owusu OBE 1953

Elsie works as a 'conservation' architect, regenerating public spaces such as London's Green Park Station and the UK Supreme Court building. She is collaborating on an eco-development in Ghana to bring ingenious infrastructure to emerging economies. She has her own architectural practice and is the first chair of the Society of Black Architects.

Aldo Rossi 1931–1997

An accomplished Italian architect and later a product designer, Aldo Rossi became known (by others) as a leading light in the **Post-Modern** movement. He was also an accomplished writer on urban theory and produced many great drawings. His main product design work was completed during the 1980s when he produced many iconic artefacts for Molteni and Alessi (covered later in this chapter).

San Cataldo cemetery in Modena, Italy, designed by Aldo Rossi

Product design

Marcel Breuer 1902–1981

One of the most iconic modern chairs of the 20th century was designed by Marcel Breuer, the head cabinet maker at the **Bauhaus** during its development. His Wassily Chair, the first ever to be made from tubular steel, was inspired by bicycle handlebars. The leather seat appears to float on air and was considered a ground-breaking design at the time. Breuer went on to become an accomplished architect.

Aljoud Lootah 1983

Shape and form are at the heart of Aljoud's designs. With her studio in Dubai, she produces furniture, lighting and objects where geometry and repeat patterns characterise her work. She is inspired by traditional crafts and reflects some of their intricate details into her work. She was named Young Designer of the Year at the 2013 Arab Woman Awards, and now has pieces exhibited in galleries internationally.

Q7 Describe how Marcel Breuer's 'Wassily Chair' follows the key principles of Bauhaus design.

Kusheda Mensah

A designer of furniture and lifestyle pieces, Kusheda's work explores how to add some fun into a functional environment, creating curvy and tactile pieces. She carefully selects her textiles and uses recycled foam to help make her production line more environmentally friendly. Sustainability is also core to her business and she has collaborated with Adidas using post-consumer recycled PET for a collection of abstract pieces.

Karim Rashid 1960

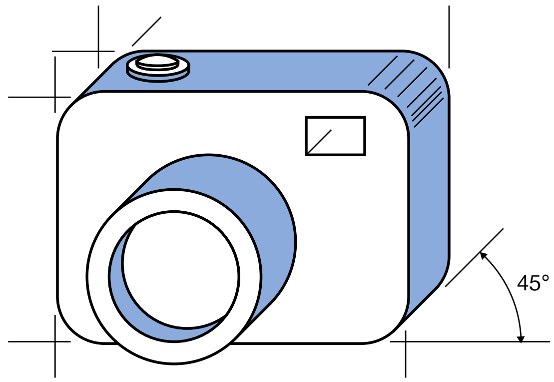
Karim is an award-winning designer, producing striking interior designs, luxury goods and high-tech products for clients such as Audi, Hugo Boss, Sony Ericsson and for stylish hotel and restaurant brands around the world. His work is sensual yet minimal with a bright colour palette. He holds an Honorary Doctorate in Art and Design and is a regular guest lecturer at universities and conferences. His work is exhibited in many museums including MoMA and Centre Pompidou.

Sculpture and graphic artworks in the renovated interior of The University of Naples Metro station, designed by Karim Rashid

Drawing techniques

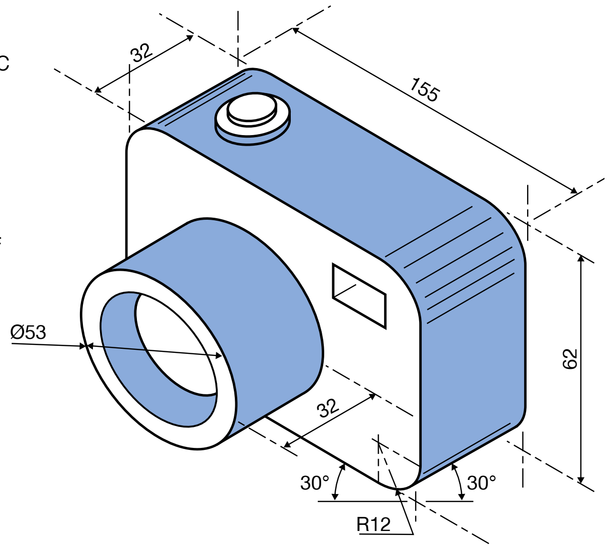
There are three main types of 3D drawing styles that you are likely to use within your portfolio. These vary in their level of complexity to produce and have different advantages and disadvantages.

Oblique projection uses a 45-degree angle to draw lines that represent the depth of the side (end) and the top (plan) of the drawing. The front of the drawing is face on to the viewer which actually creates a visual lie. It is impossible to see the front of a cuboid straight on and also see the side and the top.



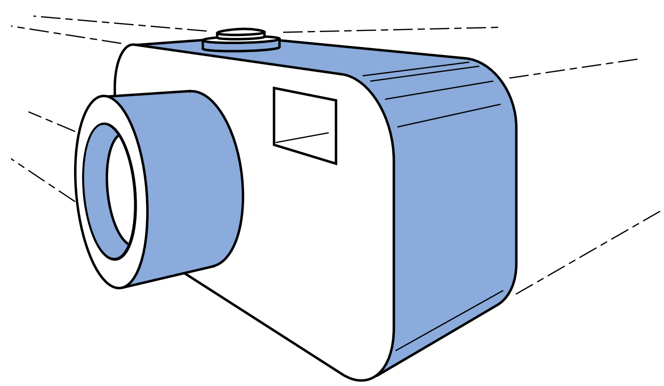
Oblique projection is a technique that can get an idea across quickly and simply. It can be very useful in the early stages of developing ideas.

Isometric projection uses a 30-degree angle and is much more realistic. For a basic cuboid, all of the height, width and depth lines follow the 30-degree isometric grid lines. Dimensioning can be done accurately and, by using simple techniques, complex shapes can be constructed or carved out of the main cuboid.



Isometric projection is very good for design ideas that have a geometric shape. With some practice, it is also good to convey ideas quickly and to show where components and parts fit in relation to others.

Two-point perspective uses two **vanishing points** that are set to the outer edges of the page. The main **construction lines** that create the width and depth are all projected back to the two vanishing points.



Two-point perspective gives the most realistic view as it emulates the way the viewer's eye sees perspective, meaning that things get smaller the further away they are. It is great technique to give a realistic view of what a product or prototype might look like. It is not so easy to add dimensions, in comparison to isometric projection.

Q4 Which 3D drawing technique would you choose if you were intending to make an accurate prototype of a product?

Chapter 48 – Material management and marking out

Objectives

- Understand how effective design planning can minimise waste
- Be aware of how design adaptations and use of tessellation can save time and materials
- Understand how to calculate the surface area and quantity of required materials
- Understand the value of using measurement and marking out to create an accurate and quality prototype
- Understand the use of datum points and coordinates
- Be able to recognise and characterise the appropriate tools and methods to mark out a range of materials to create prototypes

Planning

The key to material management is to plan ahead. Working out the best way to fit the required parts of a product onto the material efficiently is not as straightforward as one might imagine. Material tends to come in specific sizes, depending on the type of material. Papers and boards come in ‘A series’ sizes, for example A4 sheets are 210mm x 297mm. These A series sizes are all rectangular, so if you wanted to cut a square shaped section from the sheet you would automatically have waste. However, if you wanted a number of identical squares you could get a much larger sheet and divide it up, producing less waste than using a number of smaller sheets.

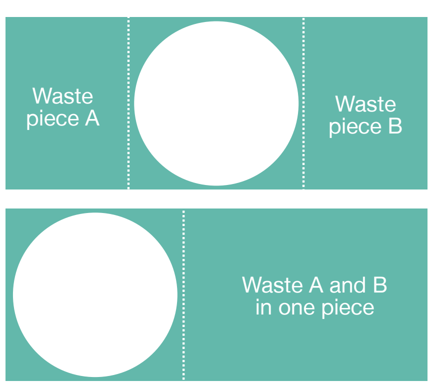
Q1 Using the standard A series paper sizes (covered in Chapter 25) answer the following questions.

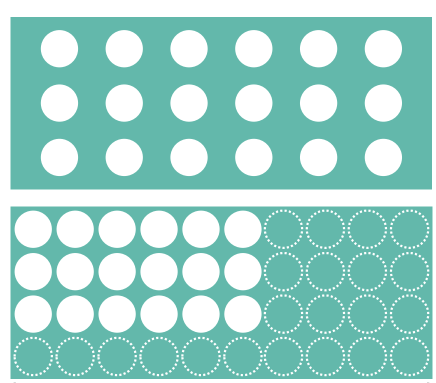
(a) Calculate the waste if you cut a 210mm square from a sheet of A4 paper.

(b) Calculate the waste if you cut a 195mm square from a sheet of A4 paper.

(c) Which larger size of A series paper would be the most economical to use if you wanted to produce 66 squares at 195mm x 195mm?

As the majority of materials come in rectangular or other specific shapes and sizes there are a few basic rules to follow in order to use materials efficiently. For example, starting from the most effective edge or corner of a sheet and not somewhere in the middle, means that the material remaining is as large as possible and is in its most useable form. If cutting discs from a rectangular sheet consider the following options:





Extra circles cut from otherwise wasted material

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- Unit 1: New and emerging technologies
- Unit 2: Energy, materials, systems and devices
- Unit 3: Materials and their working properties
- Unit 4: Common specialist technical principles
- Units 5A - 5F: Specialist material areas
- Unit 6: Designing principles
- Unit 7: Making principles

- Unit 5A: Papers and boards
- Unit 5B: Timber based materials
- Unit 5C: Metal based materials
- Unit 5D: Polymers
- Unit 5E: Textile based materials
- Unit 5F: Electronic and mechanical systems

Only the student book is AQA approved. There is currently no AQA approval process for teaching materials.

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AQA GCSE 8552 (9-1) Specification map

3.1 Core technical principles

	New and emerging technologies	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5A	Unit 5B	Unit 5C	Unit 5D	Unit 5E	Unit 5F	Unit 6	Unit 7
3.1.1	New and emerging technologies	✓											
	Energy, materials, systems and devices												
3.1.2	Energy storage and generation		✓										
3.1.3	Developments in new materials		✓										
3.1.4	Systems approach to designing		✓										
3.1.5	Mechanical devices		✓										
	Materials and their working properties												
3.1.6	Materials and their working properties			✓									

3.2 Specialist technical principles

	Common specialist technical principles	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5A	Unit 5B	Unit 5C	Unit 5D	Unit 5E	Unit 5F	Unit 6	Unit 7
3.2.2	Forces and stresses				✓								
3.2.3	Ecological and social footprint				✓								
3.2.7	Scales of production				✓								
	Specialist material areas												
3.2.1	Selection of materials or components												
3.2.4	Sources and origins												
3.2.5	Using and working with materials												
3.2.6	Stock forms, types and sizes												
3.2.8	Specialist techniques and processes												
3.2.9	Surface treatments and finishes												

Materials covered in Units 5A-F

- ✓ Papers and boards
- ✓ Timber based materials
- ✓ Metal based materials
- ✓ Polymers
- ✓ Textile based materials
- ✓ Electronic and mechanical systems

3.3 Designing and making principles

	Designing principles	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5A	Unit 5B	Unit 5C	Unit 5D	Unit 5E	Unit 5F	Unit 6	Unit 7
3.3.1	Investigation, primary and secondary data											✓	
3.3.2	Environmental, social and economic challenge											✓	
3.3.3	The work of others											✓	
3.3.4	Design strategies											✓	
3.3.5	Communication of design ideas											✓	
3.3.6	Prototype development											✓	
	Making principles												
3.3.7	Selection of materials and components												✓
3.3.8	Tolerances												✓
3.3.9	Material management												✓
3.3.10	Specialist tools and equipment												✓
3.3.11	Specialist techniques and processes												✓

The content in each section of the textbook covers the same specification points as the corresponding downloadable teaching unit, e.g. Section 1 complements Unit 1.

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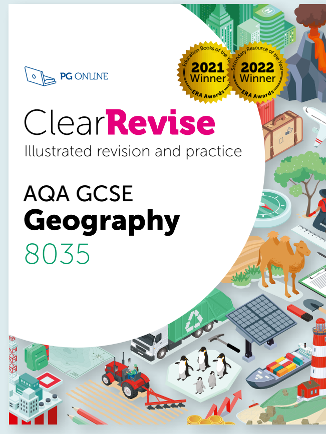

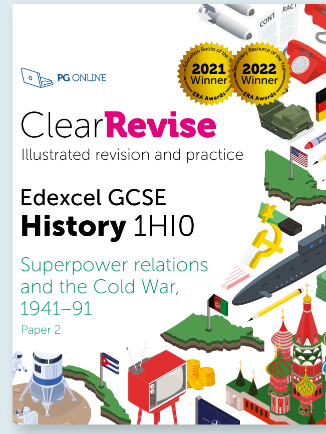

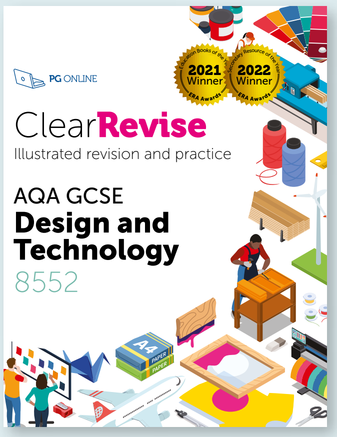

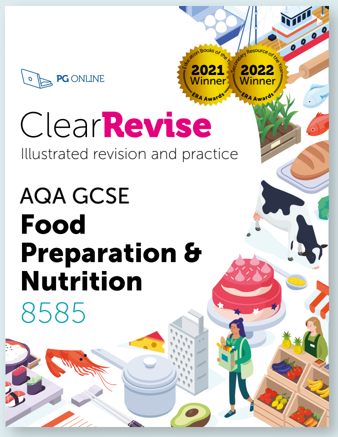

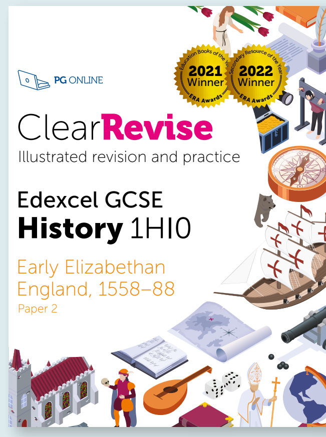

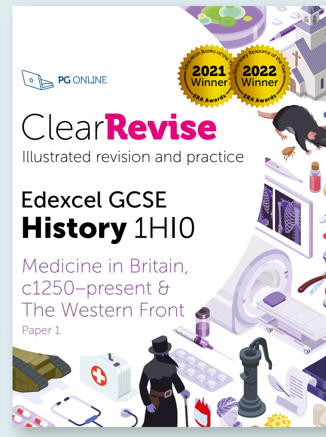

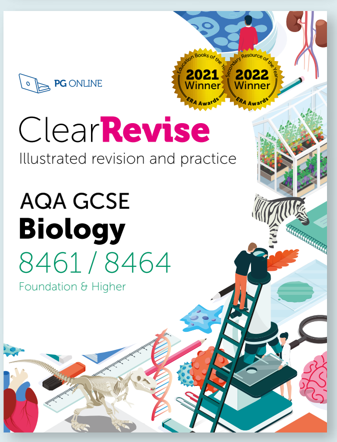

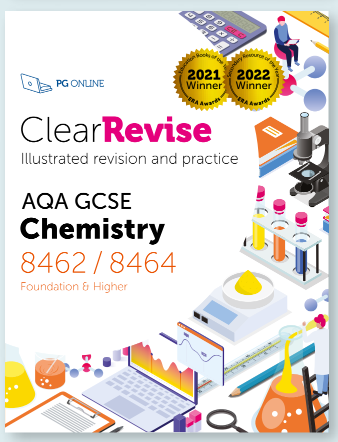

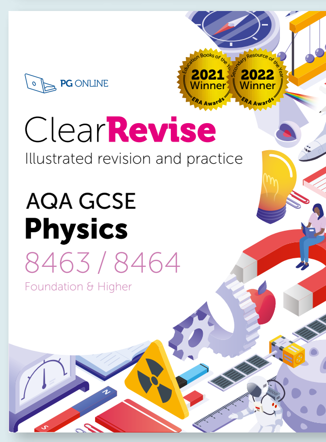

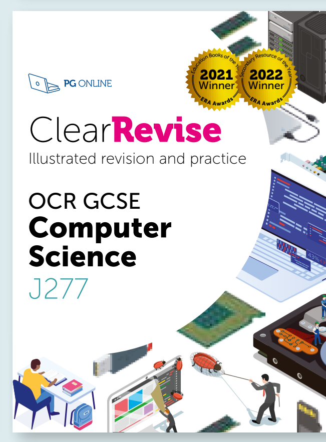

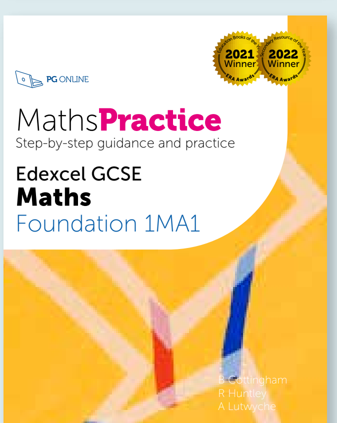

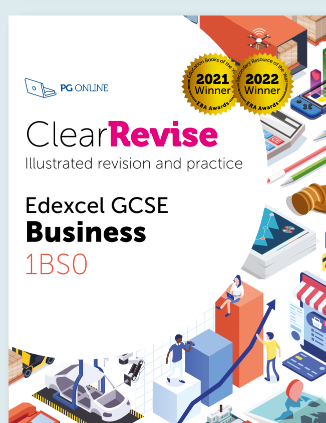

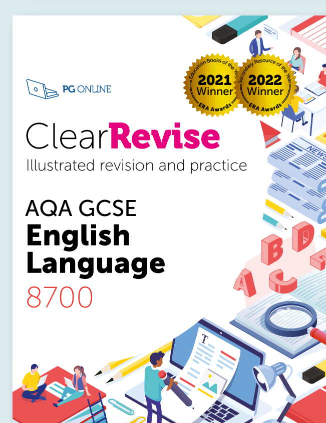

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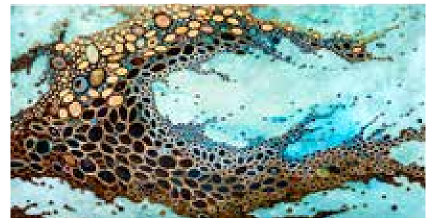

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Mike Ross has 25 years' experience in the education sector. He has taught Design and Technology in secondary schools in the state and private sectors. He has held Head of Design and Technology and Head of Year roles in schools and has been the Lead Design & Technology Editor for a top education publisher, writing and overseeing both printed and digital resources.
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