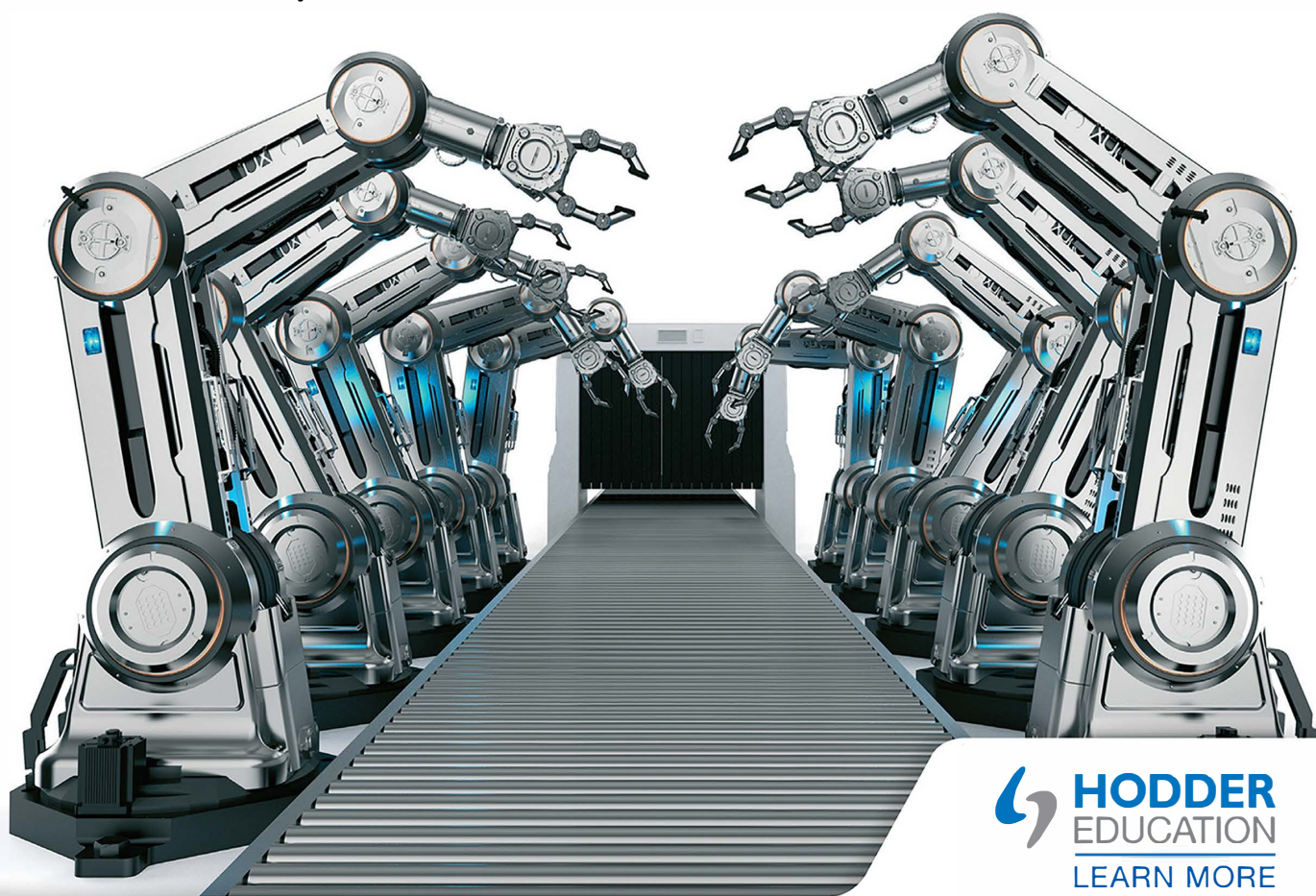


Pearson Edexcel GCSE (9–1)

DESIGN AND TECHNOLOGY

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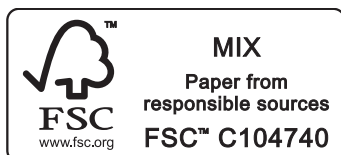
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My revision planner

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1 Core content

1.1 The impact of new and emerging technologies

1.1.1 Industry

REVISED

- Modern factories increasingly use **automated production**. Robots are often used to complete some repetitive and monotonous tasks previously carried out by humans, which can lead to unemployment.
- **Computer-aided manufacture (CAM)** machines are used where high volumes of identical products of a consistent high quality are needed.
- People often move to different countries to find suitable employment or where there is a shortage in a particular workforce. This is referred to as **demographic movement**.
- Science and technology parks are areas where like-minded businesses come together to form centres of excellence.

Automated production: a production method of using machinery controlled by computers.

CAM: computer-aided manufacture.

1.1.2 Enterprise

REVISED

- A privately-owned business is owned by the company founders, or their families, or by a small group of investors whose shares in the company are not publicly traded.
- Crowd funding is an internet-based scheme allowing people to raise money to get a business idea started, such as the manufacture of a new product. Investors lend money to projects that they believe are viable.
- The UK government offers some loans and grants to new start-up businesses. Investors can get tax relief on their investments. While not all new businesses are successful, the potential to boost the economy and the provision of future employment is worth taking a risk.
- Not-for-profit organisations reinvest all profits back into the business for the benefit of all involved.



Figure 1.1 The Forest Stewardship Council® (FSC®) is an example of a not-for-profit organisation

1.1.3 Sustainability

REVISED

- **Sustainability** is about meeting today's needs without compromising the needs of future generations.
- Demand on the world's natural resources currently exceeds supply. Materials used in product design fall into two categories:
 - **finite:** resources with a limited supply that will eventually run out
 - **non-finite:** resources that can be replenished and are unlikely to run out.
- One way to reduce our environmental impact is to consider the six Rs.

Sustainability: the manufacture of goods without compromising future needs; the materials required for a product can be replenished and will not run out.

Table 1.1 The six Rs of sustainability

Rethink	Is there a better way of making the product that is less harmful to the environment? Can the design be simplified to make manufacturing easier?
Recycle	Can the product be recycled easily after it is no longer needed? Can the components and materials be separated easily? Can recycled materials be used?
Repair	Can this product be repaired easily if it breaks? Can the component parts be replaced easily?
Refuse	Consumers might not buy a product if it is not environmentally friendly or if it is made by people working in poor conditions.
Reduce	Can the number of component parts, new materials or packaging be reduced? Can the manufacturing process be simplified to reduce the energy used?
Reuse	Can any parts be reused after it is no longer needed? Could the product be reused for something else once its primary use is no longer required?

Transportation

- Each product has a **carbon footprint** from its manufacture and the distance it travels until it is purchased and used.
- Transportation costs/carbon footprint can be reduced by:
 - sourcing materials closer to manufacturing centres and potential markets
 - using energy-efficient means of transporting goods, for example electric or **hybrid vehicles**.

Pollution

The manufacture and use of any product leads to an increase in pollution levels. There are ways to reduce the level of pollution.

- Manufacturers could use cleaner energy sources, such as solar or wind.
- Goods could be transported using electric vehicles that do not emit greenhouse gases.
- Products could be built to last and easy to repair, causing less waste.
- Products need to be disposed of carefully if they cannot be recycled, avoiding landfill where possible.

Demand on natural resources

- Natural resources and productive land enable us to produce the goods and services that sustain and support modern lifestyles.
- The **ecological footprint** is a measure of the impact that human activity has on the environment.
- Humanity's ecological footprint is currently 1.7 Earths – the Earth takes about 18 months to replace what we use in 12 months. If this continues, we will create an **ecological deficit**.

Carbon footprint: a measure of the greenhouse gases emitted by human activity.

Hybrid vehicles: vehicles that are both petrol and electric, so emissions are reduced.



Figure 1.2 Hybrid technology reduces carbon emission from vehicles

Ecological footprint: a measure of the impact that human activity has on the environment.

Ecological deficit: when resources are being used up faster than nature can replenish them.

Waste generated

- Many products are designed with built-in or planned **obsolescence**, meaning that they are not designed to be long lasting.
- Companies such as Apple introduce new products that consumers are eager to own, even though their current products still work perfectly well. This puts further strain on the world's resources, as many products are not recycled or are difficult to recycle.
- Some polymers are difficult to recycle. New technology is being developed that will allow them to be broken down more effectively and safely.

Obsolescence: the process of becoming no longer needed or wanted.

1.1.4 People

REVISED

- Developments in mobile technology and the internet make it easier for us to communicate with people all over the world. This leads to greater competition among manufacturers.
- There are downsides to this global society, which affect workers directly:
 - Importing cheap products from overseas rather than buying locally produced products can lead to job losses in our own society.
 - The use of automation leads to job losses (see Section 1.1.1 Industry on page 7).
 - Workers overseas are often paid low wages to reduce costs and maximise profit.
- The workforce of the future needs to be more adaptable, offering different skills, such as problem solving, which lead into more highly skilled jobs like engineering or computer science.
- Technological developments in **computer-aided design (CAD)** packages have changed the way designers work. All aspects of developing design ideas can be done using computers.
- Apprenticeships are work-based training programmes that allow trainees to learn on-the-job from a skilled employer. Apprenticeships are often in vocational areas, for example tailoring, engineering or carpentry.
- Society needs to be inclusive. New and emerging technologies have allowed designers to create products that meet the needs of many people, including those with disabilities and the elderly. This could be from simple hand tools to computer programs.
- Children are increasingly exposed to technology. While this can be positive, many believe it is at the expense of social interaction.

CAD: computer-aided design; software used to produce drawings and virtual models of products and systems.

1.1.5 Culture

REVISED

- People have always travelled to find better work opportunities and improve their lives. A permanent move is called **migration**. The European Union allows EU nationals to travel freely across the member states.
- Social segregation can occur when ethnic minorities cluster together to form their own society but do not fully integrate into the wider community.

Migration: the movement of people, often to find work.

1.1.6 Society

REVISED

- Many factories now operate 24/7 with people working in shifts in rotation, including night shifts. Productivity is increased, but at the expense of a work–life balance for many workers.
- People are increasingly reliant on technology. Many devices can be connected to the internet and be controlled remotely, for example controlling the lighting or heating in your home from a smart phone. This is referred to as the **Internet of Things (IoT)**.
- Advances in communication technology allows the use of video conferencing to conduct meetings with people in different locations, enabling remote working and reducing the need to travel.

Internet of Things (IoT): the interconnection of everyday products to the internet.

1.1.7 Environment

REVISED

- Burning fossil fuels to provide energy releases greenhouse gases into the environment – a major contributor to global warming.
- Developments in renewable energy allow us to make better use of alternative sources of energy, reduces our reliance on **finite fossil fuels** and lowers pollution levels.
- Many companies sell recyclable waste materials to recoup some costs. Recycling schemes allow consumers to dispose of waste safely and thoughtfully, for example collection points for old batteries in many retail outlets.
- Complex products are often difficult to recycle if the materials cannot be separated easily, for example foil-lined cardboard tube packaging from crisps, which have a metal base, metal tear off lid and polymer cap.
- Many consumers believe packaging of goods is unnecessary, particularly if the packaging used is not recycled. Eliminating the need for packaging, reducing the amount used or only using recyclable or **biodegradable** materials is better for the environment.

Finite fossil fuels: fuels that have a limited supply and cannot be replaced, for example, oil and coal.

Biodegradable: will decompose (rot) and break down without damaging the environment.

1.1.8 Production techniques and systems

REVISED

Products are manufactured under different scales of production depending on the:

- type of product being made
- quantity required
- timescale for manufacture.

Bespoke: specially made for a particular person.

Table 1.2 Different scales of production

One-off	Batch	Mass	Continuous
A single product is manufactured for a specific client need, for example a bespoke suit	A set number of identical products is produced over a set period of time, for example seasonal products	Very high volumes produced over an extended period of time to meet with the demands of mass marketing	High volume of production; manufacturing is non-stop through a 24-hour period

Exam tip

Reasons for choosing one scale of production over another vary: a uniform style and size of paper clip, for example, would be mass produced as millions are potentially needed and the style is unlikely to change. Know why different scales are used and be able to give reasons to support your answer.

- Many components, parts and materials are made in standardised measurements and sizes, and are readily available for manufacturers to use when needed.
- Just-in-time (JIT)** manufacturing is a stock control system where components, parts or materials are ordered when needed. This is an efficient, cost-effective system but is highly reliant on suppliers delivering goods on time.
- Lean manufacturing focuses on minimising waste in all areas of design through to manufacture, while maximising productivity at the same time.

Typical mistake

When a question asks you to 'explain' something, the answer requires a fact and a further elaboration of that fact. You will not gain full marks for simply listing features that do not include reasoning.

Now test yourself

- 1 Explain how automation used in industry is changing the way products are manufactured. (4)
- 2 List **two** ways an entrepreneur could gain funding for a new business venture. (2)
- 3 Give a reason why seasonal products are often batch produced. Include an example of a batch-produced product in your answer. (2)
- 4 List **two** factors that contribute to a product's carbon footprint. (2)
- 5 Describe in detail how the Internet of Things (IoT) is impacting our daily lives. (3)

1.2 Critical evaluation of new and emerging technologies

1.2.1 How to critically evaluate new and emerging technologies

REVISED

Table 1.3 Questions a designer might ask when evaluating design proposals

Budget constraints	What is the budget for the development of the product? How much is available for materials and components? This could mean using cheaper component parts, which could impact on quality.
Timescale	What is the timescale for the development of the product? What is needed to ensure it is fit for purpose and tested before launch? Failure to meet a set timescale could impact on future sales or product success.
Who the product is for	Who is the target customer? Have user needs and wants been considered? Meeting the needs and wants of users is critical for a successful outcome.
Materials used	What materials support the function of the product best? How can emerging technologies improve the product? Emerging technologies can lead to competitive advantages.
Manufacturing capabilities	What are the most efficient methods of manufacture? Can emerging technology support manufacture? 3D printing (additive manufacture) is an emerging technology that offers additional possibilities.

Additive manufacture: a system of printing layer by layer.

1.2.2 How critical evaluations can be used to inform design decisions

REVISED

Table 1.4 Applying critical thinking to contemporary problems and potential future scenarios

Natural disasters	CAD programs allow for 3D simulations of real-life disasters and help visualise how a structure might respond.
Medical advances	Emerging technology has had a major impact on the medical profession, for example the 3D printing of synthetic cartilage fits the knee joint perfectly, and the use of Nitinol (an alloy of nickel and titanium) in medical implants such as stents.
Travel	Electric cars are seen by many as the way forward. Battery technology continues to evolve and driving range will increase. Electric cars do not produce emissions, are efficient and environmentally friendly.
Global warming	The main cause of global warming is the release of greenhouse gases such as carbon dioxide into the atmosphere. Solar and wind farms are examples of technology that can help reduce these emissions.
Communication	Emerging technology in fibre optics and wireless (Bluetooth) have led to a vast range of digital devices that allow easy communication on a global scale.

Synthetic: human-made.

Nitinol: an alloy of nickel and titanium.

Alloy: a metal mixed with another metal or element (such as carbon) to improve its properties in some way.

1.2.3 Ethical perspectives

REVISED

Where was it made?

In some countries, working conditions are not considered safe. The textile industry has many examples of poor working practices.

Who was it made by?

Some countries still use child labour despite efforts to stop it. Are the workers fully trained and supported in the jobs they do?

Who will benefit?

If workers are well paid then they and their families benefit. If not, it is the manufacturer or the people who buy cheap products who benefit.

Figure 1.3 Ethical questions

Fairtrade

Fairtrade develops fair trading relationships between producers, businesses and consumers.

Social, economic and environmental Fairtrade Standards are set for all organisations involved in the supply chain.

Workers receive fair wages and also a Fairtrade Premium to invest in their business and community projects like health care and education.



Figure 1.4 The FAIRTRADE Marks

Conditions must be of a satisfactory standard to guard against **exploitation** so that workers' rights are protected.

When consumers choose products that carry the FAIRTRADE Marks, they are supporting disadvantaged workers and producers in developing countries.

Exploited: when someone is unfairly taken advantage of.

1.2.4 Environmental perspectives

REVISED

It is important that designers:

- choose materials that are environmentally friendly
- use materials from sustainable sources
- consider using less packaging or recycled packaging
- consider what happens once products are no longer needed, making recycling easier by ensuring that materials can be separated easily and reused.

Life-cycle analysis (LCA) looks at the environmental impact of a product throughout its entire life. In LCA, the following factors should be considered: source of raw materials, material processing, manufacturing, use, end of life and transportation, as well as the energy used at various points during its life cycle.

Life-cycle analysis (LCA): analysing the impact a product has on the environment during its entire life cycle.

Energy used and consumption during manufacture and transportation

- Transportation of products uses energy from fossil fuels, increasing a product's carbon footprint (see Section 1.1.3 Sustainability on page 8). Reducing transportation by using local manufacturers with locally sourced materials can reduce the carbon footprint.
- **Environmental directives** (laws) from the EU or organisations such as World Energy Council are targets for governments to work towards to reduce energy consumption and pollution, and to eliminate the disposal of hazardous waste into the environment. These directives also cover climate change, air pollution and the protection of wildlife.

Typical mistake

A life-cycle analysis is often confused with a product life cycle, which refers to the sales it achieves.

Environmental directives: laws that aim to protect the environment.

Exam tip
Questions beginning with 'evaluate' or 'analyse' require an extended answer where detail is needed to gain full marks. 'Analyse' requires reasoning in the answer, while 'evaluate' needs evidence of appraisal.

Now test yourself

TESTED

1 Explain why a limited budget could impact on the design of a new product. (3)

2 Describe **one** example where emerging technology is supporting the medical profession. (1)

3 List **four** factors a designer would look at when carrying out a life-cycle analysis (LCA). (4)

4 Explain what is meant by 'additive manufacture'. (2)

1.3 How energy is generated and stored

1.3.1 Sources, generation and storage of energy

REVISED

Table 1.5 Non-renewable energy sources

Oil	Crude oil is extracted from the Earth and refined into liquid fuels such as petrol. It can also be used to generate electricity in power stations.
Gas	Extracted through drilling and piped through the national grid to houses and factories. It can also be used to generate electricity in power stations.
Coal	Mined from the ground and burnt in power stations to generate electricity.

Issues surrounding the use of fossil fuels:

- Fossil fuels have high energy density – they hold a lot of chemical energy per kilogram of fuel – making them ideal for transportation.
- Gases such as carbon dioxide and pollutants such as sulphur dioxide are emitted when fossil fuels are burnt. This can cause breathing problems and contributes to global warming.
- Fossil fuels cannot be replaced and will eventually run out.

Table 1.6 Renewable energy sources

Wind	A wind turbine extracts energy from the wind. The blades are connected to a generator that produces electricity.
Solar	Photovoltaic (PV) panels produce electricity when exposed to the sunlight.
Hydroelectric	Dams house large turbines that trap water. When the water is released, the pressure turns the turbines and generate electricity.
Biofuels – biodiesel and biomass	Wood not used in the timber industry is chipped and used as fuel (biodiesel) instead of burning coal. In some biomass schemes plants such as soy are grown to produce materials that can be processed into biofuels.
Tidal	Energy is extracted from the rise and fall of the tide. Large turbines can be placed in areas where there is high tidal movement.

Table 1.7 Advantages and disadvantages of renewable energy sources

Advantages	Disadvantages
Renewable energy sources are non-polluting and considered better for the environment.	Initial outlay for the equipment needed for renewable energy is expensive (it produces free energy following installation, however).
Although biomass fuels release carbon dioxide as they are burned, trees are replanted, which absorb carbon dioxide as they grow. The process is classed as carbon neutral .	Wind and solar power depend on weather conditions and therefore cannot be relied on.
Manufacturers are installing equipment to recover waste energy to heat their offices. This will reduce energy bills, but is also a more ethical approach to construction.	In order to build dams to generate hydroelectric power, valleys in rural areas must be flooded. This can damage the natural habitat for wildlife.

Carbon neutral: no net release of carbon dioxide.

1.3.2 Powering systems

REVISED

- Mains electricity is delivered to homes and businesses via the National Grid using underground or overhead cables via pylons.
- Energy from solar and wind farms also contributes to the National Grid.
- Batteries store electrical power. Battery capacity varies depending on the number of cells and the voltage within each cell.
- Battery technology continues to evolve – the size of batteries has significantly been reduced but the capacity to power a device has increased.

1.3.3 Choosing appropriate energy sources

REVISED

Using renewable energy instead of burning fossil fuels is seen by many as the cleaner and greener way forward. However, there is still an environmental cost:

- Many people consider wind farms and solar panels unsightly and noisy.
- There are concerns that birds could be harmed by wind turbine blades.

Compact renewable energy sources have been developed to be used on portable devices:

- Small solar PV panels can produce a small current to recharge a battery. Flexible solar PV panels can be found on clothing and bags, which can charge a mobile phone.
- Low-powered products can be charged from a small wind generator.
- Clockwork wind-up mechanisms can provide a temporary source of power for mechanical or electronic products.
- Technology allows for electrical devices to be far more efficient in terms of energy used. For example, using **light-emitting diode (LED)** lights instead of filament lamps reduces energy consumption.
- Domestic appliances carry an energy rating label. A+++ is the most efficient; while G is the least.
- Standard connections allow products to be sold worldwide, for example USB slots on computers.
- Rechargeable products are often seen as an advantage by consumers.

Light-emitting diode

(LED): an output device that produces light when current flows from anode to cathode; they are more energy efficient than traditional filament lightbulbs.



Figure 1.5 Electronic road sign powered by solar energy

Now test yourself

TESTED

- 1 Biomass fuels are said to be carbon neutral. Explain the meaning of this term. (2)
- 2 Describe in detail **one** advantage and **one** disadvantage of wind power. (2)
- 3 Discuss the disadvantages of using fossil fuels to provide energy. (4)
- 4 State the correct name for the cells found on solar panels. (1)
- 5 Explain how technology has impacted the development of batteries. (2)

Exam tip

Make sure you fully understand the meaning of key words and terminology. This will help you to understand the context of each question and enable you to write a full and detailed answer.

Typical mistake

Read exam questions carefully and make sure you fully understand what the question is asking before attempting an answer. The main point of the question can often be missed if an answer is rushed.