Oxford Resources for OxfordAQA

# **International GCSE**

# Design & Technology

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## Section A: Core technical principles

## Chapter 1: Core technical principles

## **1.1 New and emerging technologies**

#### Topic aims

#### You will:

- have a greater understanding of how new technology has changed product manufacture
- understand that products make use of finite resources
- understand that new technologies and increased machine usage have led to pollution and global warming

#### Study tip

Ensure that you are familiar with definitions of the key terms in this chapter as exam questions will be either multiple choice or short answer.





▲ Figure 1.1: CNC tools can be used in the medical industry to precisionmake stainless steel plates and screws that are used to align bones after breaking.

- understand that designers and manufacturers need to make environmental and ethical decisions
- have a greater knowledge of how businesses can be started and how people and culture drive change in the products we use.

#### Industry

The industrial revolution in the late 1700s was a turning point for the way in which products are made. Machinery began to replace skilled craftspeople, which meant that items could be produced more easily and in larger quantities.

Today, the use of computers and new technologies has revolutionized industries.

- Buildings themselves are laid out so that production flows effectively from workstation to workstation.
- Many processes are controlled by computer systems so that items are tracked and monitored with minimal human input.
- Robotics are used on production lines to ensure consistent quality outcomes are achieved for the consumer and in the most cost-efficient way for the manufacturer.

The textile and car manufacturing industries are just two examples where new technology is used to maximize **efficiency**.

High efficiency means high output from a machine or process, with the least amount of energy input (or least amount of money).

Efficiency is calculated as output divided by input and expressed as a percentage.

#### **Tools and equipment**

- The type of industry will determine the tools and equipment needed to make certain products.
- Where products are made in smaller numbers, more flexibility is needed to allow for variation between batches. The tools, equipment, and machinery used are therefore more adaptable.
- The use of CNC (computer numerically controlled) lathes, milling machines, and routers, along with laser and plasma cutters, offers manufacturers this flexibility.

### Production techniques and systems

#### Automation

**Automation** is the use of machines to carry out tasks with limited human input. Automation can be used to make part of a product or the whole thing and is a key development in manufacturing products in quantity. It is expensive to set up an automated system in industry and requires a specialist workforce to program the machines.

Robots are an example of automation. Robotic arms, for example, can be fitted with different tools, allowing them to perform tasks ranging from welding to spray painting.

There are many advantages to using robots, including:

- they can work more quickly than humans
- they do not get tired and can work for longer periods of time or continuously
- they reduce production costs
- they can work to a higher level of accuracy
- they can work in dangerous situations (with toxic chemicals, for example).

## Computer aided design (CAD) and computer aided manufacture (CAM)

The use of computers in design saves designers time and resources and allows them to share their ideas instantly across the globe. Machines such as laser cutters, 3D printers, CNC routers, and milling machines convert the design into data and manufacture the 3D object quickly.

#### Modern manufacturing systems

**Lean manufacturing** aims to minimize the number of resources used in the manufacture of products and the amount of waste produced. Waste can refer to materials, time, money, transportation, or number of people.

**Just in time production (JIT)** is a form of lean manufacturing. Products are manufactured to order and factories are organized so that components are bought in at the time they are needed in the production process. This takes away the need for storage space, which saves the company money. Cars are an example of a product manufactured in this way.

To meet the demands of the customer, factories organize their production so that machines can easily be brought into or removed from the process. This is called a **Flexible manufacturing system (FMS)**. The system can change if a different product needs to be manufactured or if demand increases.

#### Summary question

**Describe** the advantages and disadvantages of the increased use of computers within manufacture.



▲ Figure 1.2: Several robotic arms work on some cars as they pass along a production line.



▲ Figure 1.3: CAD software, although costly, can produce accurate and detailed drawings more quickly than by hand.

#### Key points

- Tools and equipment are computer numerically controlled (CNC) in many industries, as this increases efficiency.
- An automated manufacturing system is one that requires less human input.
- The car industry is an example that uses robotics to complete tasks quickly.
- Factories can be organized to minimize waste, adapt to customer demand, and get products out quickly.



▲ Figure 1.4: Apple aims to make all of its products using 100 per cent renewable energy by 2030.



▲ Figure 1.5: Wind, solar, and hydroelectric energy

#### Sustainability and the environment

#### Finite resources

**Sustainability** means the fulfilment of the needs of current generations without affecting the needs of future generations by depleting resources. **Finite resources** are available in only a limited supply and cannot be recovered once used.

Industry relies heavily on machines to do most of the work in factories, so the amount of energy needed to run them is vast. Globally this energy, in the form of electricity, is still fuelled mainly by finite resources. This is unsustainable.

Coal, oil, and gas are **fossil fuels**–finite energy resources that have taken millions of years to form. It is estimated that oil will run out in roughly 50 years and using it as fuel contributes to global warming. Designers and manufacturers need to look to alternative resources.

#### Non-finite resources

**Non-finite resources** or **renewable energy sources**, such as solar, wind, hydro-electric, tidal, geothermal, and biomass, are alternatives that will not run out. New technologies have allowed these sources to be harnessed more easily, stored, and used more efficiently than before, meaning we can be less reliant on finite resources for energy.

#### **Environmental impact**

Designers and manufacturers have a responsibility to consider the impact on the planet of the products that they design and makefrom the materials they choose, their source, the need to transport them, and the processing of the materials in factories into products, to the final disposal of the products at the end of their useful life.

All of these factors determine a product's **ecological footprint** (how the product impacts on the environment, land, and natural resources) and its **social footprint** (how the product can impact on people's lives).

Disposal of waste needs to be considered carefully to reduce the impact on the environment and to sustain the supply of finite resources.

- Recycling and reusing products means that less raw material needs to be extracted.
- Composting of biodegradable materials is more beneficial to the planet than simply disposing of unwanted products in **landfill**. Products that are disposed of in landfill sit in the ground for hundreds of years, releasing harmful gases, such as methane, into the atmosphere.
- Incineration (burning) removes the need for land in which to bury unwanted products but is still harmful to the planet. Burning polymers, for example, gives off polluting gases such as sulfur dioxide and nitrogen oxides into the atmosphere.

#### Case study

An Icelandic designer, Ari Jónsson, came up with a creative solution to the problem that 50 per cent of all plastic is thrown away in landfill after use. He created a water bottle made from red algae, which will biodegrade and dehydrate once all the water is consumed from inside.



#### Figure 1.6: Red algae (Rhodophyta)

**Global warming** is a long-term effect of burning fossil fuels. It is causing global climate change with devastating consequences.

The growth of mechanised industry, new technologies, and global transportation of materials and products has led to an increase in the use of fossil fuels being burnt for energy generation. This process releases carbon dioxide, a greenhouse gas, into the atmosphere, where it prevents heat escaping from the planet. The level of an industry's contribution to carbon dioxide buildup is measured by its **carbon footprint**.

Global warming makes it very important for designers and manufacturers to find alternative energy sources and build energy efficiency into the products they make. If a designer can make a product more energy-efficient, so it consumes less energy when in use, then it will have less impact on the planet. This way of designing is known as **continuous improvement**. This can reduce the impact on the planet for future generations.

#### Key points

- Finite resources include coal, oil, and gas.
- Sustainable design ensures that needs are met today without depleting the resources needed by future generations.
- Products can have a huge impact on the environment, whether because of the materials they are made from, how far they need to be transported, or the ways in which we dispose of them.

#### **Summary questions**

Explain the term 'sustainability'.Name a non-finite source of energy.State what has led to global warming.



▲ Figure 1.7: Emissions from factories and power stations include carbon dioxide, which causes global warming.

#### Study tip

Make a list of the sources of energy under the headings 'renewable' and 'non-renewable'.



▲ Figure 1.18: Structure of a wind turbine

#### Case study

IKEA is an international company that uses solar panels on its buildings to produce renewable energy.



▲ Figure 1.20: A field of solar panels

#### **Renewable energy**

Renewable energy is energy that comes from natural sources that are replenished at a higher rate than they are consumed.

They are clean sources of energy, meaning they do not add to global warming when they are used to generate electricity, unlike fossil fuels.

#### Wind energy

Wind turbines have large blades attached to a shaft, which rotate when the wind blows. The kinetic energy of this rotating motion is converted into electricity by a generator connected to the shaft.

Windfarms are groups of turbines located together to harvest energy. These can be located offshore (out at sea) or onshore (on land, typically in rural locations).



## ▲ Figure 1.19: Gansu windfarm, located in the Gobi Desert in China, is the world's largest windfarm.

Advantages of wind energy include that:

- zero emissions are produced, meaning wind energy is clean and helps to limit global warming
- it is an inexhaustible source of energy
- constructing windfarms provides job opportunities.

Disadvantages of wind energy include that:

- turbines produce noise when the huge blades rotate and may be considered unsightly in rural locations
- turbines are expensive to construct, especially offshore, so the initial set up costs for this energy source are high.

#### Solar energy

Photovoltaic cells, or solar cells, are made from silicon and absorb the sun's light energy. This energy creates electrical charges that move in response to an internal electrical field in the cell, causing electricity to flow.

Panels of solar cells can be added onto the rooves of buildings to face the sun and maximize the amount of light energy being absorbed. They can also be positioned together in huge collections in fields. Some arrays are made to track the sun. Advantages of solar energy include that:

- like all renewable energy sources, it is a clean and carbon free source
- solar panels are becoming more efficient and more affordable for homeowners and business owners to install
- using solar panels reduces electricity bills each year.

#### Disadvantages of solar energy include that:

- arrays of solar panels can take up large amounts of land space
- some people still regard solar panels as unsightly on housing
- solar cells only produce significant electricity when it is sunny. During the night, and in countries with less exposure to the sun during the day, solar cells are less effective.

#### Tidal energy

Tidal energy is produced by the natural rise and fall of the oceans' tides and currents, which are created by the gravitational pull of the moon.

Electricity is generated using turbines, which are placed in tidal streams and are turned by the flow of the water. The rotational energy of the turbine is then converted into electricity using a generator.



Advantages of tidal energy include that:

- water is hundreds of times denser than air, which makes tidal energy more powerful than wind
- tides are predictable, which makes this form of energy reliable.

Disadvantages of tidal energy include that:

- turbines, with rotating blades, can cause injury to marine life
- barrages (dams) stop the migration of some species
- the noise produced by the turbines rotating can upset species of animals that use echolocation.

#### Summary questions

Briefly explain how wind energy is produced.

Describe the problems linked with tidal energy.



▲ Figure 1.22: Sihwa Lake tidal power station in South Korea is the largest in the world. It uses a sea wall barrage that is 12.7 km in length to harness the tide's energy.

#### Study tip

Be able to list an advantage and a disadvantage for each of the renewable energy sources.

#### Key points

- Wind, solar, and tidal are all clean, renewable sources of energy.
- Although these renewable energy sources do not add to global warming, they still have impacts on the environment.

#### Hydro-electrical energy

The energy of falling water is used to create electricity. There are two ways in which this can be done: by finding a place where water naturally drops, like a waterfall, or by building a dam in a reservoir to hold back the water until it is needed and then letting it fall.

**3.** A generator is connected to the turbine, which converts the energy from the moving water into electricity.

1. Water is collected at a higher level and, using pipes, it flows down to a turbine.



#### **Case study**



#### ▲ Figure 1.23: The Cachi hydroelectric dam, Costa Rica

Costa Rica is the first country to obtain 100 per cent of its electricity supply from renewable sources. Two-thirds comes from hydro-electricity. **2.** As the water flows downwards, pressure increases, forcing the turbine at the bottom to rotate.

#### ▲ Figure 1.24: How hydro-electricity is made

Advantages of using hydro-electric energy include that:

- flowing water carries a huge amount of kinetic energy that can be converted into electrical energy
- it is a reliable source as water has a constant and steady flow
- hydro-electric plants can adjust the amount of water flowing to the turbine, depending on the amount of energy they need to generate.

Disadvantages of using hydro-electric energy include that:

- large areas of land are needed to create reservoirs, changing the landscape and affecting habitats
- hydro-electric plants are costly to set up
- rotting organic matter at the bottom of the reservoirs releases methane, a greenhouse gas, into the atmosphere.

#### **Biomass energy**

Renewable organic material, from plants and animals, is burned to generate energy. Energy is created from biomass in the same way as from fossil fuels. It is burned to heat water to create steam, which turns a turbine connected to a generator.

#### Some examples of biomass include:

- timber residue (a by-product from timber mills and processing)
- purpose-grown energy crops, such as corn and soy
- farming waste (waste from crop processing and animal dung).

Advantages of biomass energy include that biomass as an energy source is carbon-neutral. This means that, although carbon dioxide is produced when biomass is burned, the plants that are grown to be used as biomass absorb about the same amount of carbon dioxide when they are growing.

Disadvantages of biomass energy include that:

- it is less efficient than fossil fuels, meaning less energy is produced from burning the same mass
- if trees are felled to be used as biomass and not replaced, deforestation can occur
- large amounts of space are needed to grow energy crops.



#### ▲ Figure 1.25: How biomass is carbon-neutral

#### Summary questions

Describe how energy is made from hydro-electric plants.Explain why biomass is considered carbon-neutral.List examples of biomass materials.

#### Skills activity

Copy and complete the table to show which renewable energy source would be the best solution in each scenario.

Scenario	Renewable energy type
A home in Mexico needs a cost-efficient way of generating electricity.	
In China, an inexhaustible supply of energy is needed to pump water.	
In Europe, farmers want to find a profitable use for waste from crops.	

#### Study tip

Remember how electricity is produced as you may be required to describe this for any of the energy sources in this unit.

#### Key points

- Hydro-electricity is a reliable and energy-efficient source of renewable energy.
- Biomass is a carbon-neutral form of energy.
- Both hydro-electric plants and biomass energy production require large areas of land.