



*'I will take responsibility for my learning, be intellectually curious and work independently at school and at home.'*



**The Regis School**  
The best in everyone™  
Part of United Learning

# PRODUCT DESIGN

EXAM BOARD: **AQA**

COURSE CODE: **8552**

| TOPIC NUMBER                            | TOPIC  | TOPIC NUMBER                            | TOPIC               |
|---|--|---|---------------------|
| <b>1. NEW AND EMERGING TECHNOLOGIES</b> |  | <b>3. DEVELOPMENTS IN NEW MATERIALS</b> |                     |
| 1.1                                     | Industry   | 3.1                                     | Modern Materials    |
| 1.2                                     | Enterprise and effective business innovation                   | 3.2                                     | Smart materials     |
| 1.3a                                    | Sustainability: impact of resource consumption on the planet   | 3.3                                     | Composite materials |
| 1.3b                                    | The Environment : Impact of resource consumption on the planet | 3.4                                     | Technical textiles  |
| 1.4a                                    | People   | 3.5                                     | Electrochemicals    |
| 1.4b                                    | Culture  | <b>4. APPROACH TO DESIGNING</b>         |                     |
| 1.4c                                    | Society  | <b>5. MECHANICAL DEVICES</b>            |                     |
| 1.5a                                    | Production techniques and systems 1                            | <b>6. ROTARY SYSTEMS</b>                |                     |
| 1.5b                                    | Production techniques and systems 2                            | <b>7. CORE PRINCIPLES</b>               |                     |
| <b>2. ENERGY GENERATION AND STORAGE</b> |  | 7.1                                     | Paper & board       |
| 2.1                                     | Fossil fuels   | 7.2                                     | Natural timbers     |
| 2.2                                     | Renewable energy   | 7.3                                     | Manufactured boards |
| 2.3                                     | Nuclear Energy   | 7.4                                     | Metals and Alloys   |
| 2.4                                     | Mechanical Power   | 7.5                                     | Polymers            |
| 2.5                                     | Electrochemicals   | 7.6                                     | Textiles            |
|   |  | 7.7                                     | Sustainability      |

Name: .....

Tutor Group: .....

# New and emerging technologies: Industry

## Introduction

**The use of new and emerging technologies has an impact on the design and organisation of the workplace.**

The industrial revolution, which began around 1760, was assisted by the discovery of harnessing water power to drive machinery. The invention of the steam engine then led to greater automation.

Before the industrial revolution, most people lived in the countryside working on the land. Automation led to larger workshops, mills and factories, so more people moved away from the countryside to find work. Towns and cities grew up around areas of manufacture. Gradually a society based on consumerism & enterprise developed. People had money to buy goods & services and manufacturing boomed which is the structure of society that we still live in today.

## Key words

**Automation** – the use of machines to do a task automatically without much, or any, human input.

**Robotics** – robots are programmed by humans and then they run automatically. Humans are only needed to monitor the robots and repair them if they break down.

**JIT** – Just in Time increases efficiency by only accepting goods when they are needed in production, saving money on storage and levels of stock held.

**CAM** – Computer aided manufacture(ing)

**CNC** – Computer numerical control machines such as laser cutters

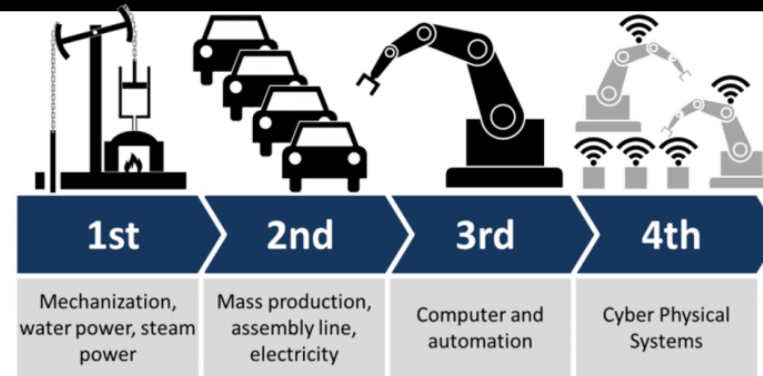
**RPT** – Rapid prototyping machines such as 3D printers

## Exam Tips

You must be able to explain the impact of new and emerging technologies on:

- the design and organisation of the workplace including automation and the use of robotics and
- Discuss the potential effects of the use of new and emerging technologies on employment

## Key Facts to Memorise



| Advantages  | Disadvantages  |
|---|--|
| <ul style="list-style-type: none"> <li>• Robots can increase the speed of production as they can work faster than humans and don't need to rest. This means they can also be cheaper to use.</li> <li>• Robots can work with high accuracy and consistency with no mistakes, so the quality of products is better which reduces costs.</li> <li>• Robots can be used in dangerous situations where it would be unsafe for humans</li> </ul> | <ul style="list-style-type: none"> <li>• Robots can replace human workers so there is less employment available</li> <li>• Robots can be very expensive to buy</li> <li>• Robots can't carry out tasks that require human judgement</li> </ul> |

## Buildings and the place of work

The development of the internet, improvements in ICT and the speed of data transfer across the Globe has allowed teams of people to collaborate remotely, rather than in a single place of work. Software has been developed to enable teams of designers to work on one project simultaneously, even from different parts of the world. Project designs can then be sent to machines for prototyping.

## Exam Questions

1. Describe 3 advantages of a company becoming more automated.
2. List the positive and negative effects that fully automated robotic production lines have had on employment.

## Stretch

- A. How might automation have affected the hierarchical structure of an organisation's staff?

## Further Links

[www.bbc.com/bitesize/guides/z46s4wx/revision/4](http://www.bbc.com/bitesize/guides/z46s4wx/revision/4)

[www.bbc.com/bitesize/clips/zjsjmp3](http://www.bbc.com/bitesize/clips/zjsjmp3)

[www.technologystudent.com/pd/f14/poster\\_globalisation1.pdf](http://www.technologystudent.com/pd/f14/poster_globalisation1.pdf)

# New and emerging technologies: Enterprise and effective business innovation

## Introduction

New and emerging technologies are used by creative people to produce innovative ideas.

There are many opportunities for creative people to get their ideas noticed by potential investors

## Key words

**Enterprise** – an idea is grown into a business proposal that has commercial viability in a product

**Investor** – a company or individual who is willing to lend money to allow a new enterprise to develop – think Dragon’s Den

**Start-up business** – A company that has come up with an idea that has the potential to grow into a profit-making business

**Patent** – ensures that original ideas, discoveries and inventions remain the intellectual property of the person who invented them It is a legal process of proving that you are the first person to have registered this idea or invention

**Crowd funding** – Usually an internet based way to gain small contributions from many investors who believe the product or idea has a future.

**Virtual marketing and retail** – the use of websites, social media, email and digital marketing to reach a wider audience to promote a product, service or idea.

**Search engine optimisation** – companies aim to make their website appear on the first page of search results for as many relevant keyword requests as possible.

**Cooperatives** – an enterprise that is owned and run by its members who may be it’s workforce or its customers.

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

## Exam Tips

Effective business innovation helps to drive enterprise.  
Explain how enterprise is based on the development of :

- an effective business innovation
- crowd funding
- virtual marketing and retail
- co-operatives
- fair trade.

## Key Facts to Memorise



👍 Increased sales

👎 Sometimes complicated / difficult to navigate

👍 Relatively cheap to set up and run

👎 Sometimes complicated / difficult to navigate



**Donation:** money is given but not returned

**Debt:** Investors hope to receive their money back, sometimes with interest

**Equity:** Investors have the opportunity for a share in the business



👍 Can increase purchasing and marketing power

👍 Are easy to form with limited liability

👎 Often have limited resources or funding

👎 Can be hard to manage efficiently, which can reduce motivation



## Exam Questions

1. Give 2 reasons why virtual marketing and retail can result in increased sales for a retailer.
2. Which low cost methods of self-promotion and advertising could young designers use to get their ideas noticed?

## Stretch

Explain 3 benefits of being part of a co-operative

## Further links

[www.co-operative.coop/about-us/history](http://www.co-operative.coop/about-us/history)

[treadingmyownpath.com/2014/05/15/fair-trade-what-it-means-what-it-does-and-how-you-play-a-part/](http://treadingmyownpath.com/2014/05/15/fair-trade-what-it-means-what-it-does-and-how-you-play-a-part/)

[jobloving.com/infographics/trading/trading-infographic-babushka-darling-midwest-fair-trade-fest-2013/](http://jobloving.com/infographics/trading/trading-infographic-babushka-darling-midwest-fair-trade-fest-2013/)



## New and emerging technologies: Sustainability: Impact of resource consumption on the planet

### Introduction

Our planet has to provide all of our basic human needs, such as food, shelter and warmth. Humans have learned to use and manipulate many of Earth's natural resources to help provide these essential as well as many non-essential products as well. The long term sustainability of the planet's resources is very much in the forefront of responsible design when new and emerging technologies are invented or discovered.

### Key words

**Finite resources** – are limited in supply or cannot be reproduced. Use of these should be avoided where possible or used only in small amounts for important reasons where an alternative cannot be used.

**Non-finite resources** – are in abundant supply and are unlikely to ever run out; they can be grown and replaced at the rate at which they are being used.

**Life cycle Assessment** – is a way for companies to assess the environmental impact of a product during the different stages of a product's life.

### Further links

[www.technologystudent.com/pdf14/POSTER\\_LIFECYCLE1.pdf](http://www.technologystudent.com/pdf14/POSTER_LIFECYCLE1.pdf)

[www.technologystudent.com/despro\\_fls/revise3.html](http://www.technologystudent.com/despro_fls/revise3.html)

[www.technologystudent.com/pdf14/poster\\_poly lactide.pdf](http://www.technologystudent.com/pdf14/poster_poly lactide.pdf)

[www.technologystudent.com/pdf11/rev\\_cards\\_life2.pdf](http://www.technologystudent.com/pdf11/rev_cards_life2.pdf)

### Exam Tips

- Understand that new technologies need to be developed and produced in a sustainable way.
- Be aware of the impact that resource consumption has on the planet
- Understand how the environment can be protected by responsible design and manufacturing
- Understand how waste can be disposed of with the least impact on the planet
- Understand the positive and negative impacts new products have on the environment

### Key Facts to Memorise

#### Impact of the use of resources

- CO2 emissions
- Impact on the environment through mining or harvesting
- Maintenance and repair costs, appropriate use of material
- Welfare of workers in the supply of the material; Fairtrade etc...
- Transportation methods and distance travelled
- Impact on availability or scarcity
- Ethical and moral issues



**Extraction and processing:** the amount of energy used to extract raw material from the earth or produce it from farming and process it ready for manufacture

**Manufacturing and production:** Energy needed to process resources into a saleable product

**Distribution:** Packaging and transportation of the product to the end user

**In use:** the energy that the product and any related consumables used during its working life or useful lifetime.

**End of life:** The energy that is required to recycle or dispose of the product.

The LCA can highlight a number of ethical questions for a company to consider about reduction in energy consumption and use of raw materials. Responsible companies can then decide how to neutralise any negative effects; for example planting trees

### Maths/science links

Taking into consideration the ecological and social footprint of materials.

### Exam Questions

1. Give 2 examples of finite resources and 2 examples of non-finite resources.
2. What can a company learn by conducting a life cycle assessment?

### Stretch

A. Why should finite resources be avoided or used in limited amounts?

# New and emerging technologies: The environment: Impact of resource consumption on the planet

## Introduction

We are now living in a society where everybody should take responsibility for recycling to ensure that:

- The resources we have last as long as possible
- Landfill sites do not fill up too quickly

There has been a population explosion since the beginning of the 20<sup>th</sup> Century which has led to accelerated use of all natural resources. The consequence of this is that resources are being used up at a very fast rate. Some new technologies are being developed to try to reduce this negative impact.

## Key words

**Built in obsolescence** – products that are deigned not to be upgradable

**Continuous improvement** – The workforce strives to find any possible way to make adjustments to working practices in order to save time, money and resources.

**Efficient working** – Just In Time, lean manufacturing methods. An ‘energy walk’ a trained member of staff turns off unnecessary lighting, heating and other appliances.

**Pollution** – By conducting an LCA a company will find out how much pollution is being created and therefore enable them to plan a reduction strategy.

**Global warming** - A boom in greenhouse gases caused by global manufacturing has caused a gradual rise in the average temperature of the Earth’s atmosphere and oceans.

**Carbon offsetting** – companies are able to consider their products sustainable by offsetting their negative impact through activities that reduce carbon emissions.

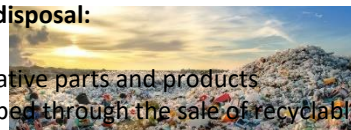
## Exam Tips

- Understand that new technologies need to be developed and produced in a sustainable way.
- Be aware of the impact that resource consumption has on the planet
- Understand how the environment can be protected by responsible design and manufacturing
- Understand how waste can be disposed of with the least impact on the planet
- Understand the positive and negative impacts new products have on the environment

## Key Facts to Memorise

### Benefits of careful planning for waste disposal:

- Less raw material is needed
- Waste materials are reused for alternative parts and products
- Some of the cost of materials if recouped through the sale of recyclable waste
- Energy to heat and power a business may be generated.



| Technologies with a negative impact                            | Technologies with a positive impact                             |
|--|---|
| Overuse of finite & non-recycled materials                     | Use only renewable materials from managed sources               |
| Use of components that are hard to repair or recycle           | Use renewable energy  |
| Fossil fuels to power manufacture                              | Use recycled and recyclable materials                           |
| Products with high power consumption                           | Design products to be repairable, reusable and fully recyclable |
| Built in obsolescence  | Produce products with lower power consumption                   |
| Component parts travel long distances and are shipped globally | Design products with fewer components and less weight           |
|  | Design products that are upgradable so their life is extended   |
|  | Create products that are sources, produces and sold locally     |
|  |   |

## Maths/science links

Taking into consideration the ecological and social footprint of materials.

## Exam Questions

Wind up radios and torches have had a very positive influence in developing countries. What factors do you feel make wind-up products of this type sustainable and environmentally friendly?

## Stretch

Explain how carbon offsetting helps to reduce the overall CO2 emissions of a company.

## Further links

[www.technologystudent.com/prddes1/waste1.html](http://www.technologystudent.com/prddes1/waste1.html)  
[www.technologystudent.com/prddes1/waste3.html](http://www.technologystudent.com/prddes1/waste3.html)  
[www.technologystudent.com/prddes1/envirmod1.html](http://www.technologystudent.com/prddes1/envirmod1.html)  
[www.technologystudent.com/prddes1/envirmod2.html](http://www.technologystudent.com/prddes1/envirmod2.html)  
[www.technologystudent.com/prddes1/upcycling1.html](http://www.technologystudent.com/prddes1/upcycling1.html)  
[www.technologystudent.com/prddes1/downcyc1.html](http://www.technologystudent.com/prddes1/downcyc1.html)  
[www.technologystudent.com/prddes1/contin1.html](http://www.technologystudent.com/prddes1/contin1.html)  
[www.technologystudent.com/prddes1/contin2.html](http://www.technologystudent.com/prddes1/contin2.html)  
[www.technologystudent.com/enrflsh/foot1.html](http://www.technologystudent.com/enrflsh/foot1.html)  
[www.technologystudent.com/enrflsh/foot3.html](http://www.technologystudent.com/enrflsh/foot3.html)  
[www.technologystudent.com/enrflsh/foot4.html](http://www.technologystudent.com/enrflsh/foot4.html)

# New and emerging technologies: People

## Introduction

People across the world can have very different needs and tastes, and products successfully launched in one country can be a complete failure in another.

## Key words

**Consumer choice** – the global market place has led to a huge increase in choice and means that prices are kept low due to higher competition

**Technology push – Technology Push** is when research and development in new **technology**, drives the development of new products. **Technology Push** usually does not involve market research. It tends to start with a company developing an innovative **technology** and applying it to a product

**Market pull** – describes consumer demand as the driving force behind new products

**Changing job roles** – the pace of development and the growth in digital and social media means that some of the traditional jobs of the last century cannot be relied on to last.

## Further links

<http://www.technologystudent.com/prddes1/revcardtec1.html>

## Exam Tips

- How technology push/market pull affects choice.
- Changing job roles due to the emergence of new ways of working driven by technological change

## Key Facts to Memorise



### Market Pull



Analysis of the consumer market, along with an understanding of human needs and desires, enables the 'gap in the market' to be filled. Market pull also puts pressure on companies to constantly improve their products so that they keep their share of the market through brand loyalty as well as attracting new customers.

### Changing job roles

Some estimates predict that two-thirds of children who are about to begin their education will have jobs that do not yet exist. Job roles are already changing due to an increase in computer technology and artificial intelligence.

- Some offices are now connected through virtual connections (conferencing) and mobile communication allows for home working or working while travelling.
- Companies will need people with technological skills who can respond quickly to change.
- People will need to become skilled in new technology such as the film industry where CGI animation is increasingly used and automation is threatening the jobs of the less skilled.

## Exam Questions

1. Name 3 products that would sell well in one country, but not in another. Justify your answers
2. What are the pros and cons of a satellite navigation system over a traditional map?

## Stretch

- A. Describe the positive and negative factors of a global market place for:
  - (a) The manufacturer
  - (b) The consumer
- B. How has the development of rechargeable battery technology affected the function and form of mobile phones over the last 30 years?
- C. Why does being first to market with a new product give a company a competitive advantage?
- D. Digital photography has changed the way photographs are viewed and processed, taking over from traditional cellulose acetate film. How has this affected job roles in the area of photography?

# New and emerging technologies: Culture

## Exam Tips

Changes in fashion and trends in relation to new and emergent technologies. Respecting people of different faiths and beliefs

## Further links

[www.technologystudent.com/pdf14/display7.pdf](http://www.technologystudent.com/pdf14/display7.pdf)

## Introduction

Fashion and trends, faiths and beliefs can affect product development. Some parts of the world are still dominated by one type of culture, especially where a government or a particular religious belief has a very powerful hold over the population. Designing products for these countries may be considered easier, as there is less diversity and the majority of people have similar lifestyles. The downside of this is that they may require a limited range of products.

In the UK, and especially in large cities, there is a very diverse mix of cultures, and selling a product to this type of market can be quite challenging as so many factors need to be considered.

## Key words

**Fashion** is defined as the dominant style in a given time period. Fashion affects areas of society including clothing, makeup or furniture.

**PDM** – product data management – helps manufacturers analyse what is in or out of fashion in real time

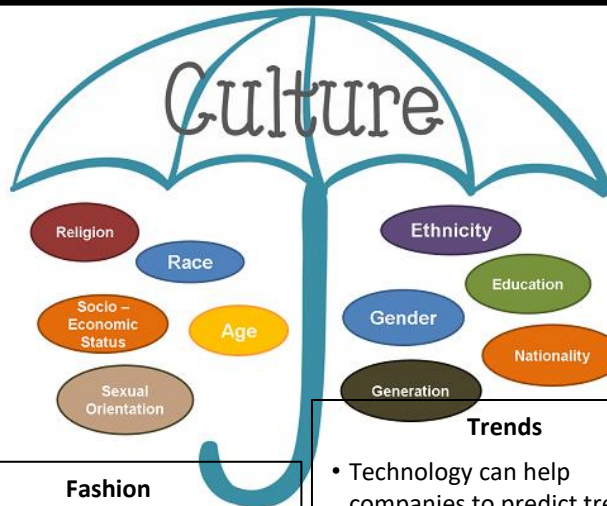
**Trends** reflect the general direction or development towards something new or different

**Lead time** is the amount of time it takes for a company to deliver a product to market from the start of the design process.

**Faiths and beliefs** – people from different cultures may have very different faiths and beliefs (which can be based on factors like religion, politics, vegetarianism, age or gender)

**Culture** is the shared general beliefs or customs of a specific group of people.

## Key Facts to Memorise

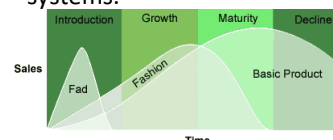


### Fashion

- Fashions come and go relatively quickly, so new manufacturing technologies allow manufacturers to respond quickly to the latest fashion.
- Mobile communication and social media mean that the latest fashions can be found more easily.

### Trends

- Technology can help companies to predict trends, helping them to respond quickly.
- Trends may have different lead times so companies must have flexible manufacturing systems.



### Faiths and beliefs

People follow the rules of these as it is their measure of what they feel is right or wrong. Manufacturers must be careful to research their market to ensure that:

- Their products do not give offensive images or messages
- Their products do not use materials which are against the market's beliefs.
- They are aware of their workers' needs such as breaks for worship or particular clothing requirements.

## Exam Questions

1. What should a company do to keep up-to-date with the latest trends in their sector?
2. What type of market testing should a company use to see if a product is ready for launch?

## Stretch

- A. Explain what is meant by the term 'culture' with regard to people.
- B. Describe 3 ways the level of demand for a product will change as a trend develops



# New and emerging technologies: Society

## Exam Tips

You need to be able to identify and explain how products are designed and made to avoid having a negative impact on others

## Exam Questions



Describe 2 ways in which the TV remote controller could be used for visually impaired users.

## Introduction

Responsible design companies consider the environment before profit. The areas of design that are considered to be responsible include one or more of the following products that:

- Are made from renewable materials
- Reduce carbon emissions and/or other greenhouse gasses in use
- Reuse existing materials or use recycled materials
- Are designed to be 100% recyclable
- Are designed to help or ease suffering or that promote fair trade
- Are made and sold locally to avoid transportation costs and associated pollution
- Are organisations that are not-for-profit and where all money is reinvested to support good causes.

## Key words

**Prosthetic** – any artificial body part, such as a limb, a heart or retinal implant

## Further links

<https://www.designcouncil.org.uk/sites/default/files/aaset/document/the-principles-of-inclusive-design.pdf>

## Key Facts to Memorise

### Design for the disabled

The 1 billion people around the world living with disabilities can benefit from technology to help them live a long, healthy, independent and engaging life. This includes designs for:

- Assistive technology, which covers small devices such as pencil grips and text-to-speech readers to larger lifting devices and all terrain wheelchairs that can scale uneven surfaces.
- Prosthetic limb technology where the electrical activity in the body can be harnessed, providing the user with a new degree of control.



### Design for the elderly

The average age of the population is increasing. It is important that we address the needs of this part of the population so that elderly people have a purpose and sense of wellbeing, including designs for:

- Communication and accessible social media or monitoring devices
- Mobility, including transportation for short distances
- Independence with mechanical / electronic aids for normal activities at home or away from home



### Design for different religious groups

Designers must consult with members of religious groups to consider their beliefs and to ensure that the design is suitable as otherwise they could lose potential customers.

- Some manufacturers have a range of designs for a product that meets the needs for each group and will not standardise the needs of religious groups.
- Technology can aid religious groups through improved communication

## Stretch

- Explain 2 ways in which new and emerging technologies are improving independence of the elderly.
- Explain 2 ways in which new and emerging technologies are allowing individuals who are blind to enter the workplace.



# New and emerging technologies: Production techniques and systems

## Introduction

The use of computers in industry has grown enormously over the last 30 years. As a result the way products are designed and manufactured has become increasingly automated. Computers are now used in all areas of design and manufacture.

## Key words

**PDM** – Product data management: All information about a production system is stored centrally, updated live and accessible. It reduces mistakes, ensures team work and allows for accurate costing and forecasting of production progress.

**CAD** – Computer aided design: The most common file types to output CAD are: .DFX, .STL and .OBJ

**CAM** – Computer aided manufacture: Most CAM machines have software that converts CAD software into a language that the machine understands. This is called **post processing**.

**CNC** – Computer numerical control: CAD software generates machine codes which are then interpreted by the CNC machine into movements to control tools such as needles or cutters.

**FMS** – Flexible Manufacturing System:

## Further links

[www.technologystudent.com/despro\\_f1sh/revise12](http://www.technologystudent.com/despro_f1sh/revise12)  
[www.technologystudent.com/cam/cnccut1](http://www.technologystudent.com/cam/cnccut1)  
[www.technologystudent.com/prddes1/justintime1](http://www.technologystudent.com/prddes1/justintime1)  
[www.technologystudent.com/despro\\_3/lean1](http://www.technologystudent.com/despro_3/lean1)

## Exam Tips

- Understand • automation • CAD • CAM – advantages and disadvantages
- Be able to recognise and explain the use of Flexible Manufacturing Systems (FMS)

## Key Facts to Memorise

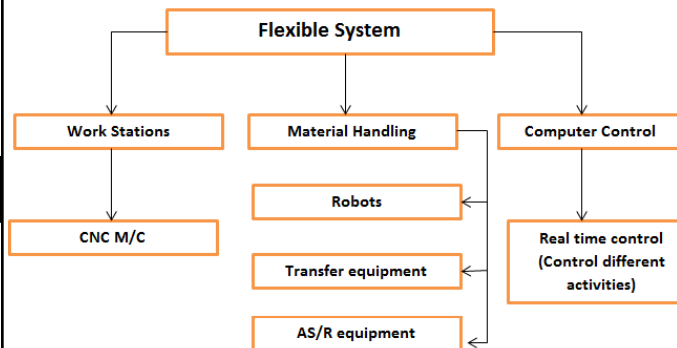
### Automation



- Automated production lines flow more easily and have less need for human interaction.
- Manual production lines of the past were slower and more expensive to operate.
- Some traditional manufacturers still rely on skilled manual labour. These products tend to be bespoke, low volume and high cost items.

### Computer aided design and manufacturing

CAD software has a number of benefits, although many designers prefer to start sketching an original idea by hand as ideas can sometimes be expressed more freely.



### FMS

A collection of automated machines that are adaptable and used in production lines where products may change regularly.

## Exam Questions

1. Which movements do the x, y and z coordinates represent on a CNC machine?
2. What are the steps that need to be taken to send a completed CAD design to a CNC machine?

## Stretch

- A. Why is it a good idea for companies to invest in product data management software?
- B. Why do some people prefer to purchase hand-built items instead of mass-produced goods?
- C. How does an FMS allow a company to respond to trends and market fluctuations?

## New and emerging technologies: Production techniques and systems

### Introduction

The use of computers in industry has grown enormously over the last 30 years. As a result the way products are designed and manufactured has become increasingly automated. Computers are now used in all areas of design and manufacture.

### Key words

**JIT – Just In Time:** Manufacturers are able to respond to customer demands more effectively. A customer's order triggers the production process and the manufacturer makes the product specifically to meet the order.

**Lean Manufacturing –** Based on an ethos of eliminating waste in manufacture



### Further links

[www.technologystudent.com/despro\\_fish/revise12](http://www.technologystudent.com/despro_fish/revise12)  
[www.technologystudent.com/cam/cncut1](http://www.technologystudent.com/cam/cncut1)  
[www.technologystudent.com/prddes1/justintime1](http://www.technologystudent.com/prddes1/justintime1)  
[www.technologystudent.com/despro\\_3/lean1](http://www.technologystudent.com/despro_3/lean1)

## Exam Tips

- Understand how just in time (JIT) and lean manufacturing contribute to manufacturing efficiencies.

### Key Facts to Memorise

## Benefits and drawbacks of JIT

| Advantages  | Disadvantages   |
|---|---|
| Lower stock holding means a reduction in storage space which saves rent and insurance costs                   | There is little room for mistakes as minimal stock is kept for re-working faulty product                                      |
| As stock is only obtained when it is needed, less working capital is tied up in stock                         | Production is highly reliant on suppliers and if stock is not delivered on time, the whole production schedule can be delayed |
| Less likelihood of stock perishing, becoming obsolete or out of date  | There is no spare finished product available to meet unexpected orders, because all product is made to meet actual orders     |
| Less time spent on checking and re-working production as the emphasis is on getting the work right first time | A need for complex, specialist stock systems  |

## 8 Wastes

The 8 Wastes are eight types of process activities that get in the way of providing value to the customer.



## Exam Questions

1. Which types of products do you think would be best produced using the JIT methods and why?

### Stretch

A.. Describe 3 characteristics of JIT that could lead to increased productivity.

# Energy generation and storage: Fossil fuels

## Introduction

There are many ways to convert energy but there are 2 main categories; fossil fuels and renewables. Countries across the World are attempting to find as many renewable sources of energy production as possible, in order to help reduce the build-up of greenhouse gases.

## Key words

### Global warming

**Turbines** – are linked to a generator to provide a supply of electricity.

**Fossil fuels** – coal, gas and oil are **finite** resources. When they are burned they produce CO<sub>2</sub>

**Biofuels** – renewable energy sources

**Shale gas** – A natural gas that is trapped in areas of shale in the Earth's crust. Shale is a sedimentary rock that can be rich source of petroleum and natural gas.

**Fracking** – A controversial process of extracting gas from the shale. It involves drilling a well down into the Earth's crust and sending high-pressure water, sand and chemical mixture into the rock to release the trapped gas. The gas travels up the drilled shaft and is collected at the well head.

## Further links

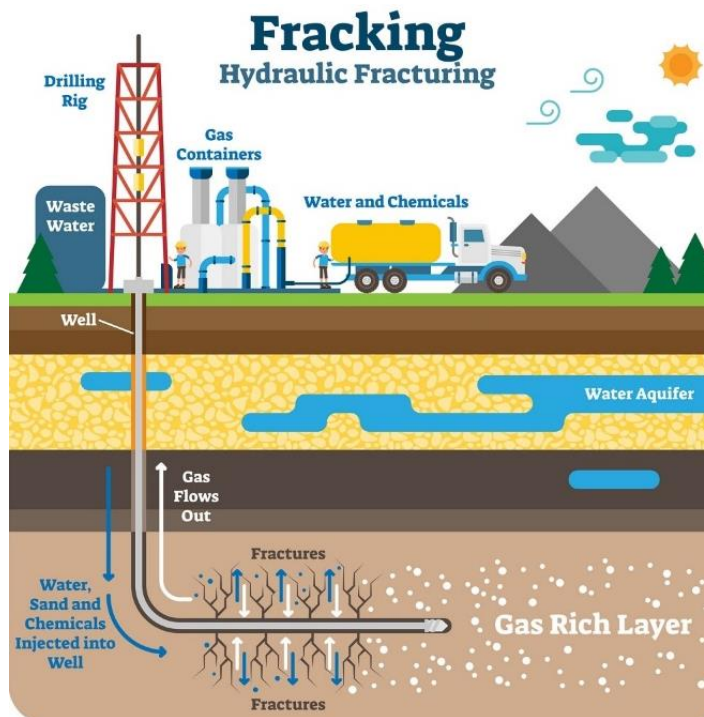
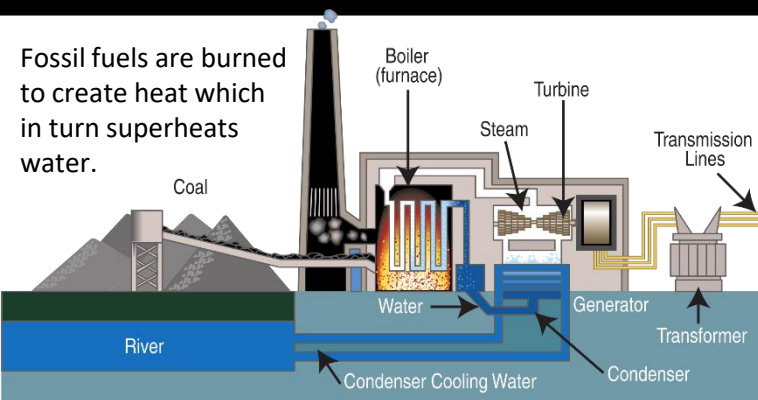
[www.youtube.com/watch?v=20Vb6hILQsg](https://www.youtube.com/watch?v=20Vb6hILQsg)

[www.bbc.co.uk/news/uk-14432401](https://www.bbc.co.uk/news/uk-14432401)

## Exam Tips

- How power is generated from: • coal • gas • oil.
- Arguments for and against each of the energy sources..

## Key Facts to Memorise



## Exam Questions

1. Fossil fuels will run out in the future. Describe two ways in which the use of fossil fuels could be reduced.
2. Explain two environmental impacts of using coal as a power source.

## Stretch

- A. Explain the steps of the fracking process used to release natural gas from shale.

# Energy generation and storage : Renewable energy

## Introduction

Energy that comes from no-finite resources is considered to be **renewable**. Nuclear energy is also sometimes included in this category as the amount of uranium it uses is unlikely to run out in under 1000 years. It also produces very low levels of CO<sub>2</sub>.

## Key words

### Global warming

**Turbines** – are linked to a generator to provide a supply of electricity.

**Fossil fuels** – coal, gas and oil are **finite** resources. When they are burned they produce CO<sub>2</sub>

**Biofuels** – renewable energy sources

**Wind**

**Solar**

**Tidal**

**Hydroelectrical**

**Biomass**

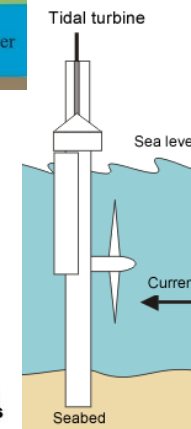
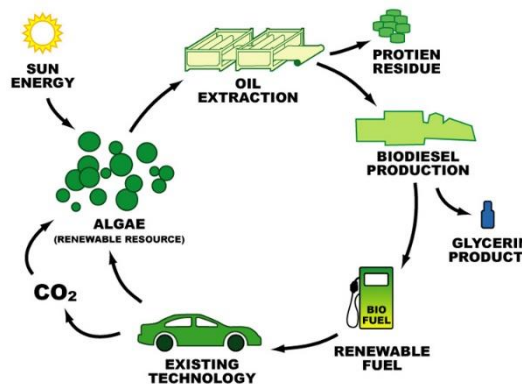
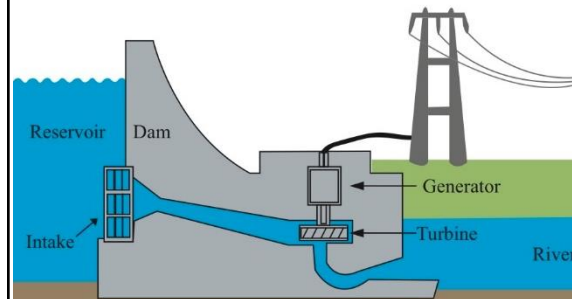
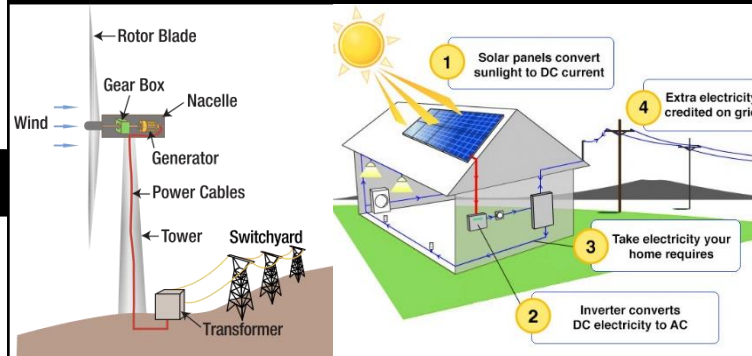
## Further links

[www.goodenergy.co.uk/how-do-wind-turbines-work/](http://www.goodenergy.co.uk/how-do-wind-turbines-work/)  
[www.evoenergy.co.uk/technology/how-solar-panels-work/](http://www.evoenergy.co.uk/technology/how-solar-panels-work/)  
[www.youtube.com/watch?v=VkJTRcTyDSyk](http://www.youtube.com/watch?v=VkJTRcTyDSyk)  
[www.youtube.com/watch?v=OC8Lbyeyh-E](http://www.youtube.com/watch?v=OC8Lbyeyh-E)  
[www.bbc.co.uk/schools/gcsebitesize/science/triple\\_ocr\\_gateway/beyond\\_the\\_microscope/biofuels/revision/1/](http://www.bbc.co.uk/schools/gcsebitesize/science/triple_ocr_gateway/beyond_the_microscope/biofuels/revision/1/)

## Exam Tips

- How power is generated from: • wind • solar • tidal • hydro-electrical • biomass.
- Arguments for and against each of the energy sources..

## Key Facts to Memorise



## Exam Questions

- 1.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?
2. list the positive factors for hydroelectric power.

## Stretch

- A.For each of the energy sources, explain the source of energy that justifies them being considered renewable.
- B. Explain what happened to the CO<sub>2</sub> during the life cycle of biofuel production and use.
- C. If biofuel is so environmentally friendly, why do you think it is not more commonly used at present?



# Energy generation and storage: Nuclear Energy

## Introduction

The most controversial method of energy production is nuclear power. Considered a clean and efficient energy source, it provides over 11% of the world's electricity. It harnesses a nuclear reaction that takes place inside the reactor vessel. Control rods are moved in or out of the reactor's core to regulate the amount of power that is generated. The reaction generates vast amounts of heat which superheats water and generates power by driving turbines and generators.

## Key words

### Global warming

**Turbines** – are linked to a generator to provide a supply of electricity.

**Fossil fuels** – coal, gas and oil are **finite** resources. When they are burned they produce CO<sub>2</sub>

### Radioactive

## Further links

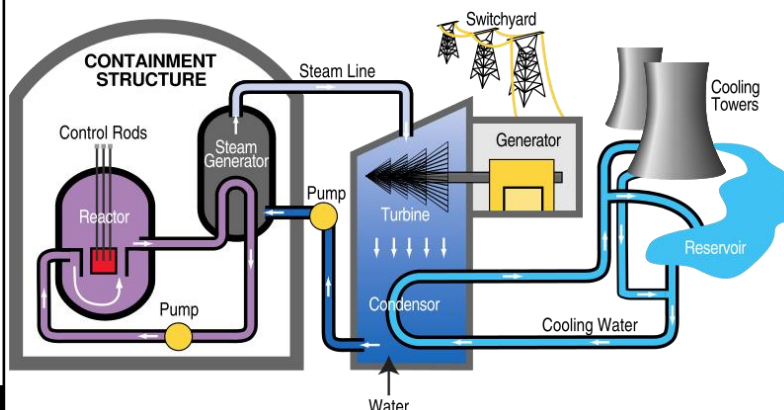
[www.youtube.com/watch?v=\\_UwexvaCMWA](https://www.youtube.com/watch?v=_UwexvaCMWA)

[www.bbc.co.uk/schools/gcsebitesize/science/add\\_gateway\\_pre\\_2011/radiation/fissionrev2.shtml](https://www.bbc.co.uk/schools/gcsebitesize/science/add_gateway_pre_2011/radiation/fissionrev2.shtml)

## Exam Tips

- How nuclear power is generated.
- Arguments for and against each of the energy sources.

## Key Facts to Memorise



The downside of nuclear power is that it is very expensive to build a reactor and the waste product from the reaction is **radioactive** and very dangerous to all forms of life. It must be contained correctly and carefully stored so that the radiation does not leak. Nuclear waste is usually stored underground as it stays radioactive for a very long time.



## Exam Questions

What are the social and environmental issues relating to the disposal of the waste from nuclear energy production?

## Stretch

- Explain one reason why coastal areas are good locations for building a nuclear power plant.
- Explain 3 risks of using nuclear energy as a power source.

# Energy generation and storage: Mechanical power

## Introduction

There are a number of ways to produce and store mechanical power. Most mechanical power used in technological products is stored by tension or compression.

## Key words

**Compression energy**

**Tension energy**

**Pneumatics** – A form of compression where gas or air is stored under pressure

**Hydraulics** – The gas or air in a pneumatic system can be swapped for a liquid, most commonly oil. This type of movement control is commonly used in car braking systems and lifting gear like forklift trucks and tractors.

**Compressor** – Hydraulic and pneumatic systems need compression for the systems to work. This is usually achieved through a type of pump called a compressor. Air or liquid is held under pressure in a storage tank. When the pressure falls below its minimum the compressor will automatically turn on and build the pressure back up.

**Kinetic energy** – energy involved in **motion**. Any object in motion has kinetic energy. Objects not in motion have **potential** energy.

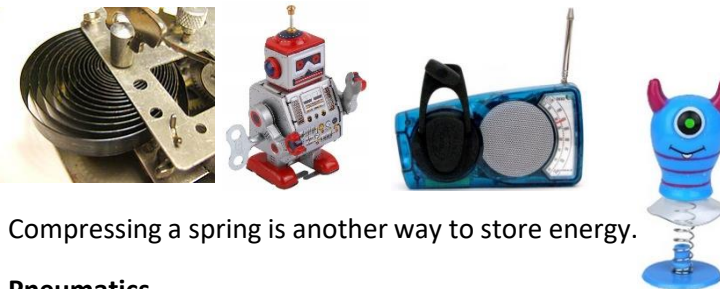
**Rotating flywheel** – a traditional way to store kinetic energy.

## Exam Tips

- Be able to identify mechanical power and understand how it is stored
- Understand pneumatics and hydraulics as examples of kinetic pumped storage systems

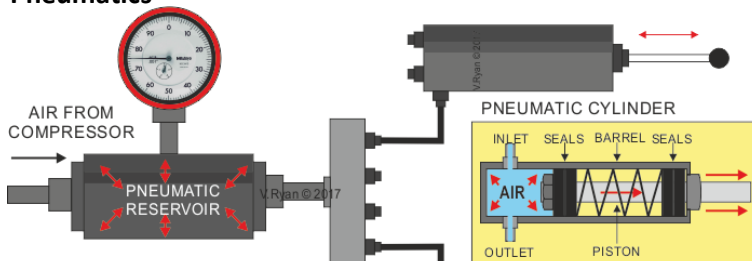
## Key Facts to Memorise

Coiled springs store physical energy from the winding process.

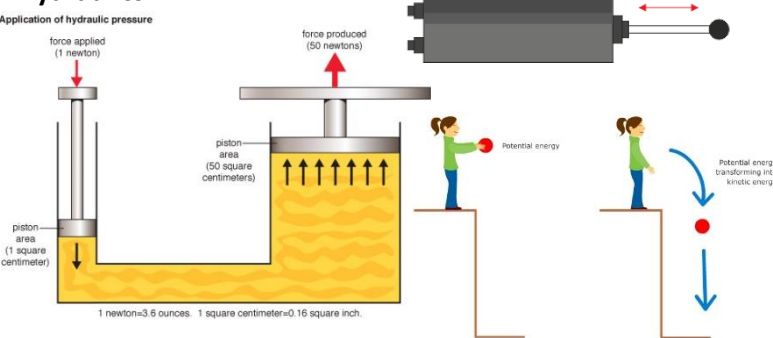


Compressing a spring is another way to store energy.

## Pneumatics



## Hydraulics



## Exam Questions

1. What methods, other than using a spring, could be used to store tension or compression energy?
2. Define the difference between a pneumatic and hydraulic system.

## Stretch

- A. Why does the spring on a wind-up product need other components such as gears and cogs in order to operate efficiently?
- B. How does a pump build up pressure in pneumatic and hydraulic systems?

## Further links

[www.bbc.co.uk/schools/gcsebitesize/design/systemscontrol/pneumaticsrev1.shtml](http://www.bbc.co.uk/schools/gcsebitesize/design/systemscontrol/pneumaticsrev1.shtml)

[www.explainthatstuff.com/how-clockwork-works.html](http://www.explainthatstuff.com/how-clockwork-works.html)

[www.explainthatstuff.com/hydraulics.html](http://www.explainthatstuff.com/hydraulics.html)

[www.youtube.com/watch?v=IqV5L66EP2E](https://www.youtube.com/watch?v=IqV5L66EP2E)

# Energy generation and storage: Electrochemicals

## Exam Tips

- Understand the functional properties of alkaline and rechargeable batteries

## Exam Questions

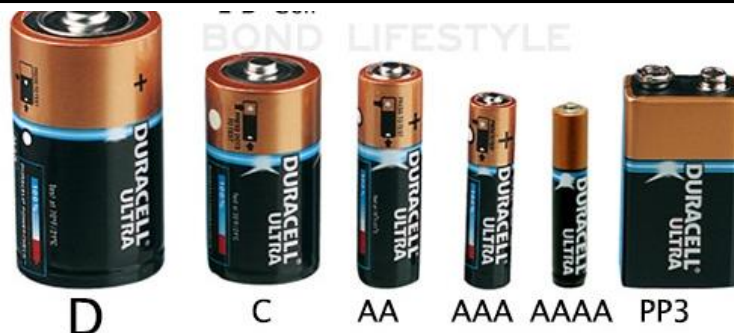
1.A PP3 battery produces 9 volts. How many cells does it contain?

## Introduction

Electrical power can be stored in batteries. They contain electrochemicals that react with each other to produce electricity.

A battery contains one or more **cells** with each cell providing 1.5 volts. Each cell has a positive side and a negative side.

## Key Facts to Memorise



## Key words

**Battery**

**Cell**

**Volts**

**Alkaline Cells** – A higher capacity for their size than traditional acid-based cells. They are more efficient and hold their charge well.

**Rechargeable batteries** – Can be charged and discharged many hundreds of times.

## Disposal of batteries

Batteries need to be disposed of correctly, as they contain toxic electrochemicals and some metals that can be harmful to the environment.

## Further links

[www.bbc.co.uk/schools/gcsebitesize/design/electronics/componentsrev8.shtml](http://www.bbc.co.uk/schools/gcsebitesize/design/electronics/componentsrev8.shtml)

## Stretch

Explain why rechargeable batteries are better for the environment.

# Developments in new materials: Modern materials

## Introduction

A good designer will use and exploit new materials and keep up-to-date with the latest developments.

## Key words

**Corn starch polymers** – Plastics that are made from vegetable starches and fully biodegradable if composted. They cannot be recycled because they so readily decompose. **Poly lactic acid / PLA, polyhydroxy-butyrate / PHB/Biopol**

### Flexible MDF



**Titanium** – A versatile metal that is usually alloyed with other metals to enhance its properties. It does not react with the human body and is therefore used by the medical profession for artificial joints and other orthopaedic uses.



**Fibre optics** – Allow digital information to travel as pulses of light along thin glass strands at high speeds. They can carry much more information than traditional copper wires and do not suffer from electromagnetic interference that can distort a signal.

**Graphene** – A million times thinner than a human hair and 200 times stronger than steel.

**LCD** – liquid crystal displays

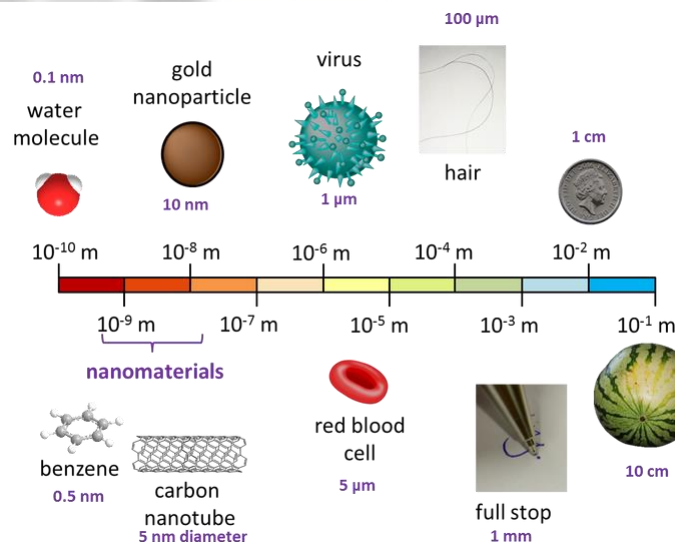
**Metal foams** – Created by injecting gas into the liquid metals



## Exam Tips

- Developments made through the invention of new or improved processes e.g. Graphene, Metal foams and Titanium. Alterations to perform a particular function e.g. Coated metals, Liquid Crystal Displays (LCDs) and Nanomaterials.

## Key Facts to Memorise



## Exam Questions

1. A cylindrical footstool measures 400m in height and has a finished external diameter of 300mm. Calculate the length of flexible MDF needed to cover the side.
2. What factors make titanium such a good material to be used by the medical profession?

## Stretch

- A. Why aren't biodegradable polymers biodegradable?
- B. Why are corn starch polymers not ideal for use outside?
- C. How can corn starch polymers help reduce the demand on finite resources?
- D. Why are so many layers needed around the inner core of fibre optic cable?
- E. Why are LCD displays ideal for use in a wristwatch?

## Further links

[www.bbc.co.uk/schools/gcsebi/tesize/design/graphics/materialsandcomponentsrev4.shtml](http://www.bbc.co.uk/schools/gcsebi/tesize/design/graphics/materialsandcomponentsrev4.shtml)



# Developments in new materials: Smart materials

## Introduction

A smart material is one that reacts to an external stimulus or input. This group of materials can react to heat, pressure, moisture, stress, PH level, lights and electricity.

## Key words

### Thermochromic

**Photochromic** – it is the **ultra violet** rays that effects the change in pigment

**Shape Memory alloy** – can remember a preset shape and return to it even after being dramatically reshaped. The stimulus for returning to the preset shape is heat or electricity.

**Nitinol** - An alloy of titanium and nickel. To program its shape memory, the nitinol must be held in the desired position and heated to 540 degrees. When cooled it can be deformed into a different shape. It will spring back to its original shape at around 70 degrees.

**Polymorph** – a non-toxic and fully biodegradable polymer in small granules. When heated to 62 degrees the granules fuse to become a mouldable substance and cool to be a solid. Can be reheated and remoulded.

**Quantum tunnelling composite** – can be a conductor or insulator. QTC varies its electrical resistance depending on the amount of pressure or stress applied to it.

**Piezoelectric material** - It is not a conductor, but produces an electrical voltage when squeezed or put under pressure. Can create a spark to ignite gas. Can be used to create sound.

**Litmus paper**

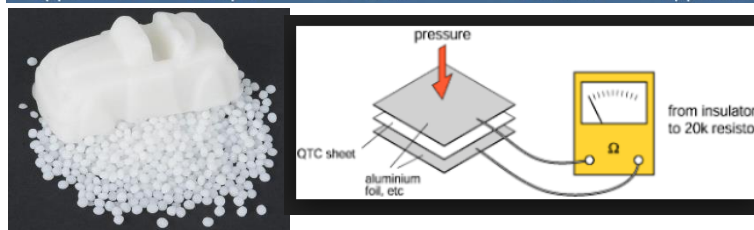
## Exam Tips

- That materials can have one or more properties that can be significantly changed in a controlled fashion by external stimuli, such as stress, temperature, moisture, or PH e.g. shape memory alloys, thermochromic pigments and photochromic pigments

## Key Facts to Memorise



## Applications of Shape Memory Alloys (SMAs)



## Exam Questions

- How could thermochromic pigments be used for packaging in the food industry?
- How could the two minutes delay in a pair of sunglasses darkening or lightening be an issue to the user?
- How could a glass office building benefit from having its windows covered in photochromic film?
- How could QTC be used in a child's toy?

## Stretch

- Explain how thermochromic pigments can be used to indicate a fever in a young child.
- Explain how a piece of shape memory alloy could be used in a fire detector controlling a sprinkler system.
- How could polymorph be used to help a person with arthritis?

## Further links

[www.bbc.co.uk/schools/gcsebit/esize/design/graphics/materialsandcomponentsrev4.shtml](http://www.bbc.co.uk/schools/gcsebit/esize/design/graphics/materialsandcomponentsrev4.shtml)

# Developments in new materials: Composite materials

## Introduction

Composite materials are formed when 2 or more different materials are combined to create a new material with improved properties and functionality.

## Key words

**GRP** – glass reinforced plastic. Glass fibre matting is covered with smooth plastic resin which sets hard with a high gloss finish. It is easily coloured and complex shapes can be formed.

**CRP** – carbon fibre reinforced plastic. Carbon fibre is a cloth woven from individual strands, the interlacing provides different patterns. It can be coloured but is often left natural.

## Further links

[www.bbc.co.uk/schools/gcsebitesize/design/graphics/materialsandcomponentsrev4.shtml](http://www.bbc.co.uk/schools/gcsebitesize/design/graphics/materialsandcomponentsrev4.shtml)

## Exam Tips

- That composite materials are produced by combining two or more different materials to create an enhanced material e.g. glass reinforced plastic (GRP) and carbon fibre reinforced plastic (CRP).

## Key Facts to Memorise

### ← Glass-reinforced plastic

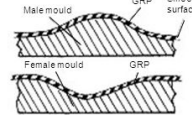
This is a forming process. Glass fibre is combined with polyester resin (thermosetting plastic) to produce a very strong structure. The glass-fibre material is layered in a mould and coated with the polyester resin; the resin sets without heat or pressure needing to be applied, and when it is set it is very strong.

#### Advantages of GRP

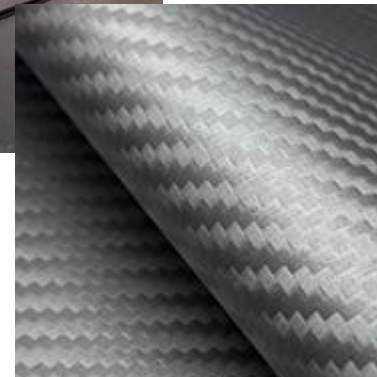
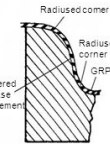
- Excellent strength-to-weight ratio
- Excellent tensile strength
- Impact resistance
- High corrosion resistance

#### Uses

- Sports car bodies
- Boat and canoe hulls
- Caravan shells



The mould is very important when forming GRP. The better the quality of the mould, the better the finish on the GRP. The moulds should be tapered to allow the product to be removed easily.



## Exam Questions

1. Draw a labelled diagram to show the construction of 3ply plwood.

## Stretch

- A. Why is it difficult to recycle many composite materials?
- B. Describe 2 reasons why GRP would be used in preference to CRP for the manufacture of a kayak.

# Developments in new materials: Technical textiles

## Introduction

A textile that has been developed with enhanced properties to withstand specific uses. The function is more important than the aesthetics.

## Key words

**Gore-tex** – A membrane sewn between layers of other fabrics. A waterproof but breathable garment which is used in a variety of outdoor clothing.

**Kevlar** – A fibre that has high tensile strength, great heat resistance and is extremely hard wearing. It is an **aramid** which are modified nylon fibres.

**Conductive fibres** – known as e-textiles. Highly conductive threads and fabrics allow an electrical signal to pass through them

**Fire resistant fabrics – Nomex and Kevlar** have been developed to withstand high temperatures and reduce combustion when exposed to a naked flame.

**Fire retardants** - can be applied to a range of regular fabrics. They are designed to produce a chemical reaction that slows down and even stops ignition taking place.

**Microfibres** – are synthetic fibres that are about 5 times finer than the human hair.

**Microencapsulation** - traps liquid or solid substances within the fibres of a material. When microencapsulated textiles are rubbed the walls of the fibre open up allowing the substance to be released.

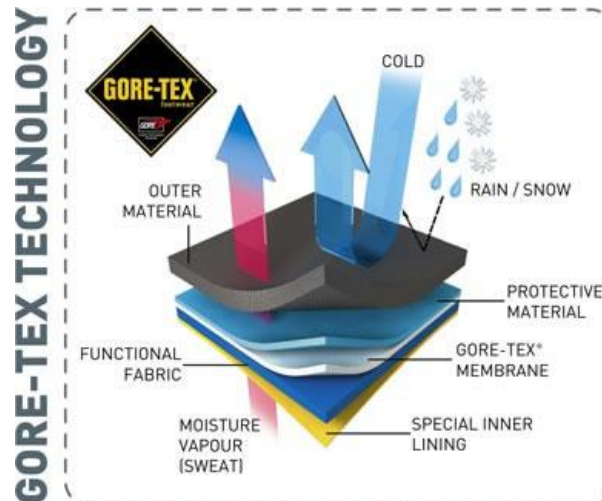
## Exam Tips

- How fibres can be spun to make enhanced fabrics e.g. conductive fabrics, fire resistant fabrics, kevlar and microfibres incorporating micro encapsulation

## Exam Questions

- How could Kevlar be used to protect students in a school workshop?
- How could conductive thread and fabric be used to improve safety features for cyclists?
- For which activities in a school workshop would wearing fire resistant PPE be of benefit?

## Key Facts to Memorise



## Stretch

- Explain how a Goretex membrane stops water from getting in, yet lets water vapour out in both hot and cold environments.
- Some microencapsulated clothing products lose their effectiveness after a number of washes. Why do you think this is the case?

## Further links

[www.bbc.co.uk/schools/gcsebi/tesize/design/graphics/materialsandcomponentsrev4.shtml](http://www.bbc.co.uk/schools/gcsebi/tesize/design/graphics/materialsandcomponentsrev4.shtml)



**TRS SP TOPIC NUMBER: 4**  
**Approach to designing**

**Introduction**

All design and manufacturing tasks are made up of systems. Within each task there can be many **subtasks** or **subsystems**.

**Key words**

**System** - parts or components that work together to control a task or activity. A system consists of inputs, processes and outputs.

**Systems diagram** - simple version of a flowchart that layout the input, process and output of a system. Separate operations involved in the process are not broken down at this stage.

**Open loop system** – has no feedback and is unable to make a decision.

**Closed loop system** – is able to make a decision using feedback.

**Inputs** – the most common input is a switch.

**Outputs** - output components are used to give off a stimulus such as light, heat, movement or sound

**Further links**

[http://www.bbc.co.uk/schools/gcsebitesize/design/electronics/industrial\\_designrev3.shtml](http://www.bbc.co.uk/schools/gcsebitesize/design/electronics/industrial_designrev3.shtml)

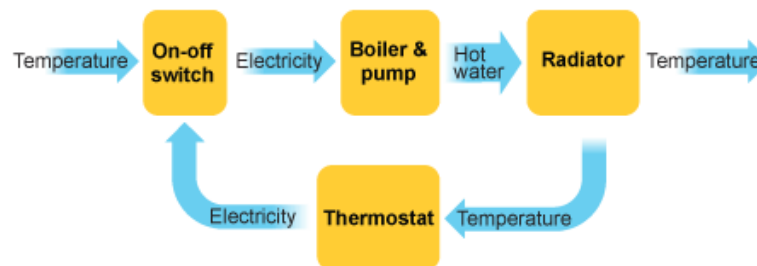
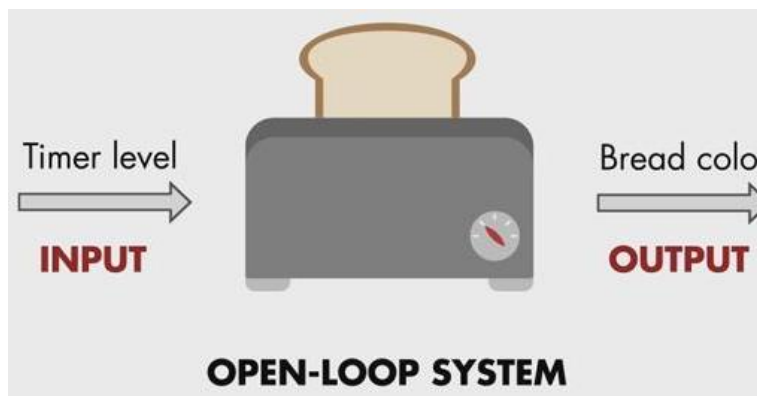
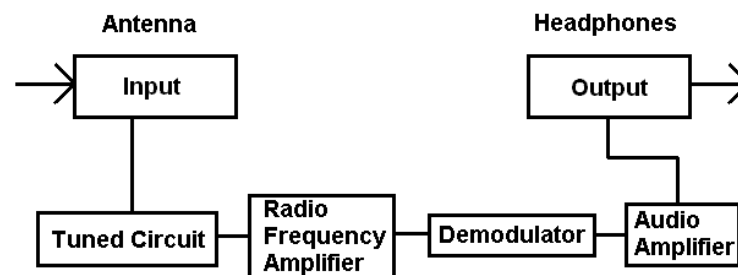
**Exam Tips**

**Inputs:** The use of light sensors, temperature sensors, pressure sensors and switches.

**Processes:** The use of programming microcontrollers as counters, timers and for decision making, to provide functionality to products and processes.

**Outputs:** The use of buzzers, speakers and lamps, to provide functionality to products and processes.

**Key Facts to Memorise**



**Exam Questions**

1. Identify the input, process, and output stages of sending a text message.

**Stretch**

A. How could a feedback loop be used to switch off an electric kettle when the water has reached 100 degrees?



## Introduction

Mechanical devices are machines or tools that have one or more parts. They use and manipulate energy to perform tasks and specific actions.

## Key words

**Movement:** Linear motion

Reciprocating motion

Oscillating motion

Rotary motion

**Levers** – a lever is a simple way to gain mechanical advantage (MA) making lifting or moving something much easier.

**Equilibrium** – Is caused when the effort and load are equal.

**First order lever (class1)**



**Second order lever ( class 2)**



**Third order lever (class3)**



**Linkages** – a mechanism made by connecting rigid parts.

## Further links

[www.bbc.co.uk/schools/gcsebitesize/design/systemscontrol/mechanismsrev8.shtml](http://www.bbc.co.uk/schools/gcsebitesize/design/systemscontrol/mechanismsrev8.shtml)

[www.technologystudent.com/forcmom/motion1.html](http://www.technologystudent.com/forcmom/motion1.html)

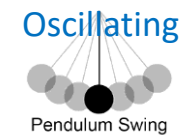
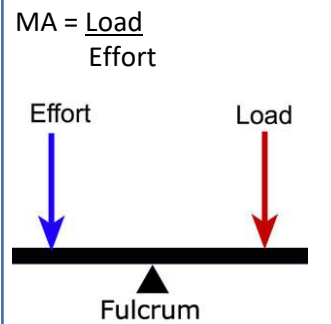
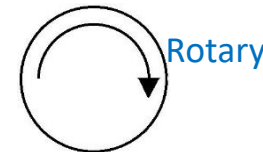
## Exam Tips

Different types of movement: The functions of mechanical devices to produce linear, rotary, reciprocating and oscillating movements.

Changing magnitude and direction of force: Levers: • first order • second order • third order Linkages: • bell cranks • push/pull.

Rotary systems: • CAMs and followers • simple gear trains • pulleys and belts.

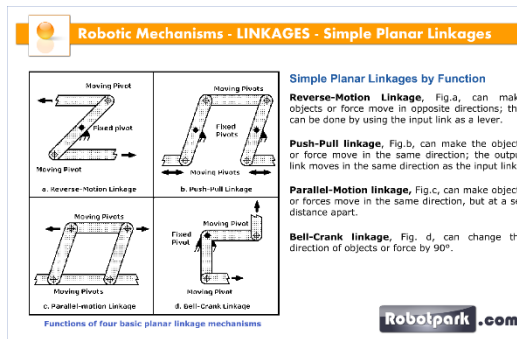
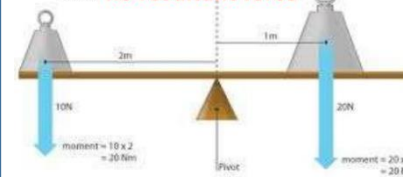
## Key Facts to Memorise



Reciprocating



If an object is in equilibrium there is **no resultant turning effect** and **no resultant force**.



## Exam Questions

- Which types of motion are associated with:  
a paper trimmer?  
the hands of a clock?  
a child's swing?
- Which class of lever best describe:  
a pair of scissors?  
a stapler?  
a nut cracker?
- Which linkage changes the direction of motion through 90 degrees?
- Which linkage converts rotary motion to reciprocating motion?

## Stretch

A. Calculate the mechanical advantage if the load was 875N and the effort was 125N. Express the answer as a ratio.

B. If A weighs 40kg and B weighs 60kg, how far from the fulcrum would A need to be for the seesaw to balance?

# Mechanical devices: Rotary systems

## Introduction

Rotary systems are used to drive mechanisms in equipment and machinery. They transfer the direction of force along different paths and through changes of angle and direction. They can also change one type of motion into another

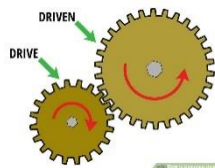
## Key words

### Cams and followers

**Cam** – a shaped piece of material attached to a rotating shaft.

**Follower** – A cam is mainly used to change rotary motion into reciprocating through the use of a follower.

**Gear trains** – A gear train consists of a cogwheel or drive 'gear' which in turn rotates the driven gear. The gear ratio is calculated by working out how many times the drive gear turns the driven gear per rotation.



**Pulley** – a grooved rimmed wheel that is used in conjunction with a drive belt to transfer movement.

**Block and tackle** – a system of two or more pulleys that can be used in combination to reduce the effort required to lift or move a heavy load.

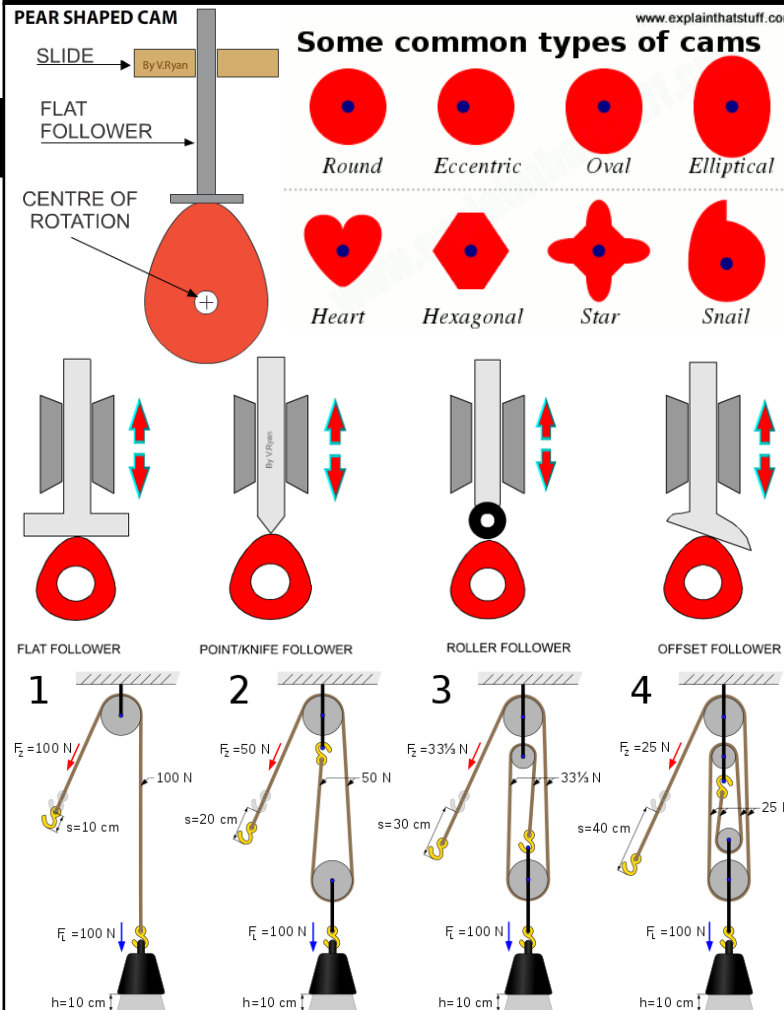
## Exam Tips

Different types of movement: The functions of mechanical devices to produce linear, rotary, reciprocating and oscillating movements.

Changing magnitude and direction of force: Levers: • first order • second order • third order Linkages: • bell cranks • push/pull.

Rotary systems: • CAMs and followers • simple gear trains • pulleys and belts.

## Key Facts to Memorise



## Exam Questions

1. Which cam could be used on an automaton to create the motion of the jaw of an animal slowly opening then snapping shut.
2. Which cam could be used on an automaton to make a mouse slowly peek out of a hole and slowly retreat back in again?

## Stretch

- A. Why is a pulley wheel grooved?

## Further links

[www.bbc.co.uk/schools/gcsebi/tesize/design/systemscontrol/mechanismsrev8.shtml](http://www.bbc.co.uk/schools/gcsebi/tesize/design/systemscontrol/mechanismsrev8.shtml)

[www.technologystudent.com/f/orcmom/motion1.html](http://www.technologystudent.com/f/orcmom/motion1.html)

[www.bbc.co.uk/schools/gcsebi/tesize/design/systemscontrol/mechanismsrev4.shtml](http://www.bbc.co.uk/schools/gcsebi/tesize/design/systemscontrol/mechanismsrev4.shtml)

## Core principles:

### Paper & board

#### Introduction

Papers and boards are usually made from wood pulp and converted to their finished forms at a paper mill. Other cellulose sources can include textiles such as cotton.

#### Key words

##### Physical Properties

**Absorbency** – how well a material may attract an element, usually a liquid such as water or moisture, but could include light or heat.

**Density** – the mass of material per unit of volume; how compact a material is.

**Electrical conductivity** – the ability to conduct electricity.

**Thermal conductivity** – the ability of a material to conduct heat.

##### Working Properties

**Strength** – the ability of a material to withstand a force such as pressure, tension or shear.

**Hardness** – the ability to resist abrasive wear and indentation through impact. Very hard materials can become brittle and can crack, snap or shatter.

**Toughness** – the ability to absorb energy through shock without fracturing.

**Malleability** – the ability to deform under compression without cracking, splitting or tearing.

**Ductility** – the ability to be stretched out or drawn into a thin strand without snapping.

**Elasticity** – the ability to return to its original shape after being compressed or stretched.




#### Exam Tips

- Know the primary sources of materials for producing papers and boards
- Be able to recognise and characterise different types of papers and boards
- Understand how the physical and working properties of a range of paper and board products affect their performance

**Common Papers:** Paper is measured by weight in grams per square metre (**GSM**)

**Common boards:** Board thickness is usually quoted in **microns** or grams per square metre (**GSM**). 100 microns is equal to 1mm of thickness. The lower the number, the thinner the paper or card.

#### Key Facts to Memorise

|                                   |  |   |
|-----------------------------------|--|---|
| Bleed proof paper                 | Used with marker pens for design ideas and final designs   |   |
| Cartridge paper                   | Pencil and ink drawings, sketching and watercolour   |   |
| Grid paper                        | Graphical, mathematical and scientific diagrams  |   |
| Layout paper                      | Creating sketches and working ideas; copying and tracing images with a variety of media          |   |
| Tracing paper                     | Copying and tracing images. Used with a light box, overlays for adaptations and working drawings |   |
| Corrugated cardboard (fibreboard) |                 | Packaging, boxes and impact protection.   |
| Duplex board                      | 2 layers of bonded card  | Cheaper version of white card used for packaging boxes. Often with a waxy coating & used for food & drinks containers |
| Foil lined board                  |               | Takeaway containers and lids, used to retain heat for longer  |
| Foam core board                   |               | Architectural models, model making, prototyping, mounting and framing of photos and artworks                          |
| Ink jet card                      |  | High quality photographic images  |
| Solid white board                 |  | Greeting cards, packaging, advertising, hot foil stamping & embossing   |

#### Exam Questions

1. Justify which papers or boards you would use for the following tasks:
  - (a) rendering a final design using coloured marker pens
  - (b) creating the net for a box to transport a cake
  - (c) producing a high quality point-of-sale advertising stand to hold leaflets.

#### Stretch

- A. Why is it better for the environment to use softwood rather than hardwood for paper pulp?
- B. A disposable coffee cup is made of duplex board with a corrugated cardboard sleeve.
  - (a) Suggest two properties of corrugated cardboard that make it suitable for use as a sleeve.
  - (b) Explain how the properties of duplex board can be modified to make it suitable to hold a liquid.

#### Further Links

[www.technologystudent.com/de\\_spro\\_flash/graphics\\_paper1.html](http://www.technologystudent.com/de_spro_flash/graphics_paper1.html)

[www.technologystudent.com/pdf15/POSTER\\_PAPERANDBOARDS1.pdf](http://www.technologystudent.com/pdf15/POSTER_PAPERANDBOARDS1.pdf)

## Core principles:

### Natural timbers

### Introduction

**Natural wood** is categorised as **hardwood** or **softwood**. This is about cell structure and not about the strength of the wood.

**Hardwood** comes from deciduous trees



**Softwood** comes from coniferous trees that are also known as evergreens



### Key words

#### Physical Properties

**Absorbency** – how well a material may attract an element, usually a liquid such as water or moisture, but could include light or heat.

**Density** – the mass of material per unit of volume; how compact a material is.

**Electrical conductivity** – the ability to conduct electricity.

**Thermal conductivity** – the ability of a material to conduct heat.

#### Working Properties

**Strength** – the ability of a material to withstand a force such as pressure, tension or shear.

**Hardness** – the ability to resist abrasive wear and indentation through impact. Very hard materials can become brittle and can crack, snap or shatter.

**Toughness** – the ability to absorb energy through shock without fracturing.

**Malleability** – the ability to deform under compression without cracking, splitting or tearing.

**Ductility** – the ability to be stretched out or drawn into a thin strand without snapping.

**Elasticity** – the ability to return to its original shape after being compressed or stretched.






### Exam Tips

- Students should have an overview of the main categories and types of natural and manufactured timbers: hardwoods including: • ash • beech • mahogany • oak • balsa softwoods including: • larch • pine • spruce

### Key Facts to Memorise

**Hardwood:** Less porous and denser cell structure; harder wearing, less likely to rot

- Balsa is an exception to the rule
- Slower growing than softwoods

| Name     |   | Characteristics   | Example Uses                                      |
|----------|---|---|---|
| Ash      |  | Flexible, tough and shock resistant, laminates well                   | Sports equipment and tool handles                 |
| Beech    |  | Fine finish, tough and durable  | Children's toys and models, furniture and veneers |
| Mahogany |  | Easily worked, durable and finishes well                              | High end furniture and joinery, veneers           |
| Oak      |  | Tough, hard and durable, high quality finish possible                 | Flooring, furniture, railway sleepers and veneers |
| Balsa    |  | Very soft and spongy, very lightweight but can snap in small sections | Prototyping and modelling –                       |

**Softwood:** Porous cell structure

- If left unprotected it can absorb moisture and rot – cedar is an exception
- Relatively cheap and readily available
- Sustainable because it grows faster

| Name   | Characteristics   | Example Uses  |
|--------|---|---|
| Larch  | Durable, tough, good water resistance, and surface finish, machines well. Loose knots | Exterior cladding, flooring, machined mouldings, furniture & joinery    |
| Pine   | Lightweight, easy to work, can split and be resinous near knots                       | Interior building (and exterior if treated), cheaper furniture, decking |
| Spruce | Easy to work, high stiffness to weight ratio. Variable results when staining          | High end furniture and joinery, veneers                                 |

### Exam Questions

- Justify which softwood you would select to construct a garden shed.

### Stretch

A.A sustainably managed forest contains 1000 trees.

(a) If these were soft wood trees felled at 25 years of age and 1/25 of the trees are harvested each year to ensure consistent supply, how many trees are felled?

(b) If the same forest was planted with hardwood trees that mature at 40 years of age and 1/40 were felled annually, how many trees would be felled each year?

### Further links

[www.technologystudent.com/designpro/natwd1.htm](http://www.technologystudent.com/designpro/natwd1.htm)

[www.technologystudent.com/pdf14/poster\\_woods2.pdf](http://www.technologystudent.com/pdf14/poster_woods2.pdf)



## Core principles: Manufactured boards

### Introduction

Manufactured boards are usually sheets of processed natural timber waste products or veneers combined with adhesives.

### Key words

#### Physical Properties

**Absorbency** – how well a material may attract an element, usually a liquid such as water or moisture, but could include light or heat.

**Density** – the mass of material per unit of volume; how compact a material is.

**Electrical conductivity** – the ability to conduct electricity.

**Thermal conductivity** – the ability of a material to conduct heat.

#### Working Properties

**Strength** – the ability of a material to withstand a force such as pressure, tension or shear.

**Hardness** – the ability to resist abrasive wear and indentation through impact. Very hard materials can become brittle and can crack, snap or shatter.

**Toughness** – the ability to absorb energy through shock without fracturing.

**Malleability** – the ability to deform under compression without cracking, splitting or tearing.

**Ductility** – the ability to be stretched out or drawn into a thin strand without snapping.

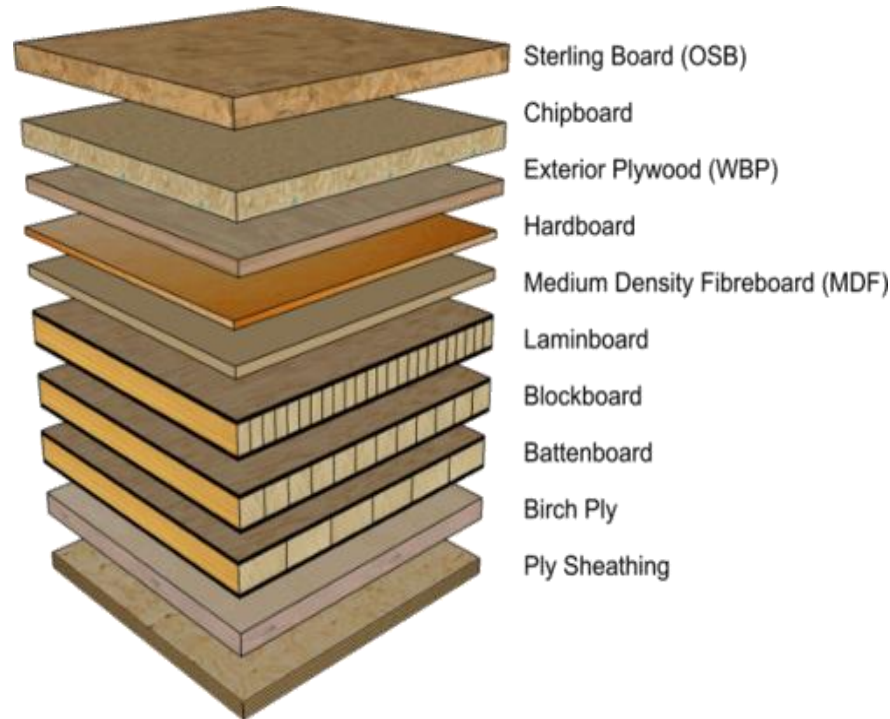
**Elasticity** – the ability to return to its original shape after being compressed or stretched.

### Exam Tips

- Students should have an overview of the main categories and types of manufactured boards

### Key Facts to Memorise

- They are made from waste wood, low grade and recycled timber.
- They can be covered with thin slices of high quality wood to give the appearance of solid wood. This is called a **veneer**.



MDF

Plywood

Chipboard



### Exam Questions

- Justify which manufactured board you would select to construct a shelf unit in a shower room.
- State two ways in which softwoods or manufactured boards can be made to appear as more expensive hardwoods.

### Stretch

- A. Explain 3 reasons why MDF is a suitable material for making the top of a school table.

### Further links

[www.technologystudent.com/joints/manmade1.html](http://www.technologystudent.com/joints/manmade1.html)

## Core principles: Metals and alloys

### Introduction

Metals generally have a high strength to weight ratio and are an essential construction material. Metals are categorised as either **ferrous** or **non-ferrous**. A third group, known as **alloys**, is created when 2 or more elements are blended together, where at least one is a pure metal.

### Key words

#### Physical Properties

**Absorbency** – how well a material may attract an element, usually a liquid such as water or moisture, but could include light or heat.

**Density** – the mass of material per unit of volume; how compact a material is.

**Electrical conductivity** – the ability to conduct electricity.

**Thermal conductivity** – the ability of a material to conduct heat.

#### Working Properties

**Strength** – the ability of a material to withstand a force such as pressure, tension or shear.

**Hardness** – the ability to resist abrasive wear and indentation through impact. Very hard materials can become brittle and can crack, snap or shatter.

**Toughness** – the ability to absorb energy through shock without fracturing.

**Malleability** – the ability to deform under compression without cracking, splitting or tearing.

**Ductility** – the ability to be stretched out or drawn into a thin strand without snapping.

**Elasticity** – the ability to return to its original shape after being compressed or stretched.

### Exam Tips

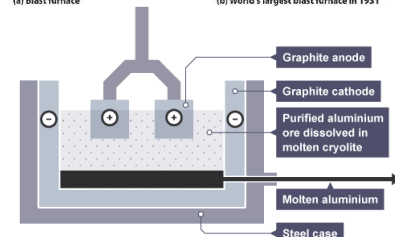
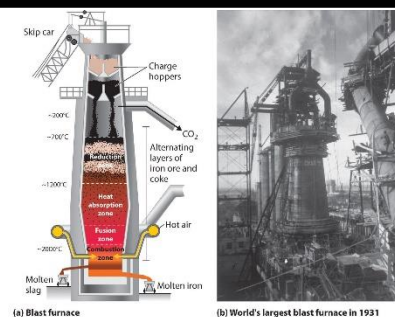
- Students should have an overview of the main categories and types of metals and alloys: ferrous metals including:
  - low carbon steel
  - cast Iron
  - high carbon/tool steel
 non ferrous metals including:
  - aluminium
  - copper
  - tin
  - zinc alloys
 including:
  - brass
  - stainless steel
  - high speed steel.

### Key Facts to Memorise

Some pure metals are mined as a whole metal but many are extracted from an **ore**. Ore is a type of rock that contains a pure metal in small quantities. The ore is obtained through mining.

**Furnace:** The extreme heat of the furnace separates the metal from the ore and it is drawn off as a molten liquid.

**Electrolysis:** Aluminium ore in the form of bauxite is crushed and the aluminium extracted by electrolysis.



#### Ferrous metals

- All contain iron
- Most are magntic and will rust if exposed to moisture without a protective finish.
- Carbon** is a common additive used to increase the hardness of iron.



#### Non-ferrous metals

- Are generally non-magnetic and do not contain iron.
- Do not rust but can **oxidise**.



#### Alloys

A mixture of at least 1 pure metal and another element.



### Exam Questions

- 1.Explain the major difference between an alloy and a pure metal.
- 2.What factors make metal an expensive material to obtain?
- 3.What is the chemical symbol for iron?

### Stretch

- A.Why is mild steel such a popular material for the construction of buildings and materials?
- B.Explain why rust can be ab issue for structural products made from low carbon steel.

### Further links

[www.bbc.co.uk/schools/gcsebi/tetize/design/resistantmaterial/s/materialsmaterialsrev2.shtml](http://www.bbc.co.uk/schools/gcsebi/tetize/design/resistantmaterial/s/materialsmaterialsrev2.shtml)

# Core principles: Polymers

## Introduction

Plastics are mainly synthetic materials made from **polymers** which are traditionally developed from finite petrochemicals such as oil, gas and coal. They are increasingly produced from sustainable sources such as vegetable starches. There are also some naturally occurring plastics such as amber and rubber.

## Key words

### Physical Properties

**Absorbency** – how well a material may attract an element, usually a liquid such as water or moisture, but could include light or heat.

**Density** – the mass of material per unit of volume; how compact a material is.

**Electrical conductivity** – the ability to conduct electricity.

**Thermal conductivity** – the ability of a material to conduct heat.

### Working Properties

**Strength** – the ability of a material to withstand a force such as pressure, tension or shear.

**Hardness** – the ability to resist abrasive wear and indentation through impact. Very hard materials can become brittle and can crack, snap or shatter.

**Toughness** – the ability to absorb energy through shock without fracturing.

**Malleability** – the ability to deform under compression without cracking, splitting or tearing.

**Ductility** – the ability to be stretched out or drawn into a thin strand without snapping.

**Elasticity** – the ability to return to its original shape after being compressed or stretched.

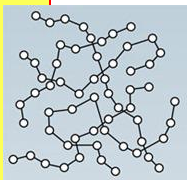
## Exam Tips

- Know the primary sources of materials for producing polymers
- Be able to recognise and characterise different types of polymers
- Understand the physical and working properties for a range of thermoforming and thermosetting polymers

## Key Facts to Memorise

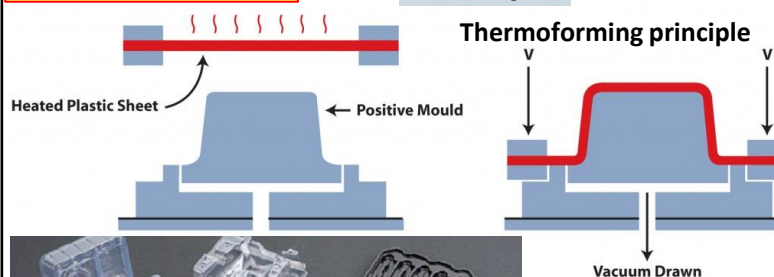
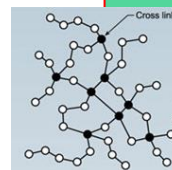
### Thermoforming Plastics

More flexible, especially when heated. Polymer chains are loosely entangled with very few cross links. This allows the chains to slide past each other when heated.



### Thermosetting Plastics

More rigid. Once formed they cannot be reformed. Long polymer chains have more cross links which stops the molecular chains moving



## Exam Questions

- 1.What molecular property allows thermoplastics to have more flexibility when heated?
- 2.What are the basic common properties that nearly all plastics possess?

## Stretch

- A.Justify which category of plastic would be best suited to making drinking straws.

## Further links

[www.bbc.co.uk/schools/gcsebiteseize/science/edexcel/fuels/hydrocarbonsrev4.shtml](http://www.bbc.co.uk/schools/gcsebiteseize/science/edexcel/fuels/hydrocarbonsrev4.shtml)

[www.technologystudent.com/pdf14/poster\\_plastics1.pdf](http://www.technologystudent.com/pdf14/poster_plastics1.pdf)

[www.technologystudent.com/joints/oiltoplas1.html](http://www.technologystudent.com/joints/oiltoplas1.html)

[www.differencebtw.com/difference-between-thermoplastics-and-thermosetting-plastics/](http://www.differencebtw.com/difference-between-thermoplastics-and-thermosetting-plastics/)



## Core principles: Textiles

### Introduction

Textiles are highly adaptable and can be constructed to maximise different properties including a very high strength to weight ratio, which means less material can be used to make strong and robust products. Textiles are available in any different forms including rolls, yarns and fibres. They can be made into a multitude of shapes and products using different processing methods.

### Key words

#### Physical Properties

**Absorbency** – how well a material may attract an element, usually a liquid such as water or moisture, but could include light or heat.

**Density** – the mass of material per unit of volume; how compact a material is.

**Electrical conductivity** – the ability to conduct electricity.

**Thermal conductivity** – the ability of a material to conduct heat.

#### Working Properties

**Strength** – the ability of a material to withstand a force such as pressure, tension or shear.

**Hardness** – the ability to resist abrasive wear and indentation through impact. Very hard materials can become brittle and can crack, snap or shatter.

**Toughness** – the ability to absorb energy through shock without fracturing.

**Malleability** – the ability to deform under compression without cracking, splitting or tearing.

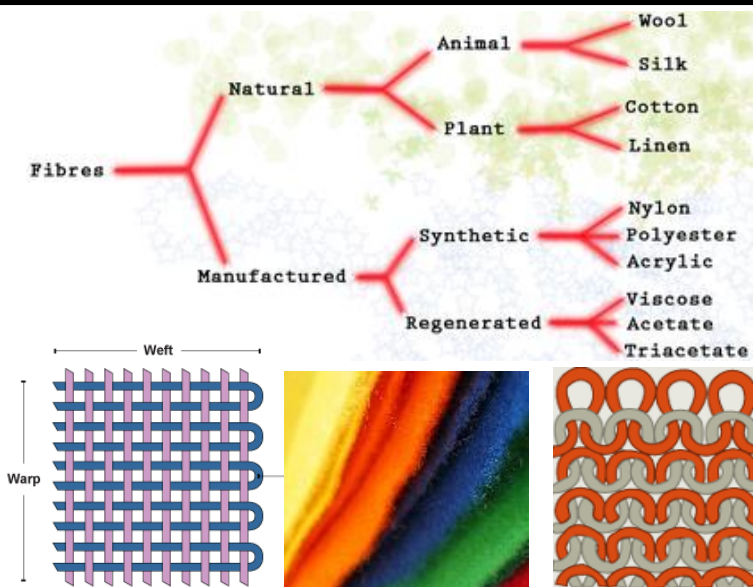
**Ductility** – the ability to be stretched out or drawn into a thin strand without snapping.

**Elasticity** – the ability to return to its original shape after being compressed or stretched.

### Exam Tips

- Know the primary sources of materials for producing textiles
- Be able to recognise and characterise different types of textile
- Understand how the physical and working properties of a range of textiles affect their performance.

### Key Facts to Memorise



#### WEAVING

Woven fabrics are made from weaving two yarns together, using a loom. The yarn that is used from the top to the bottom of the loom is the warp thread. The yarn that goes under and over the warp yarn is known as the weft thread. Where the weft thread turns around at the edge of a fabric it is known as the selvedge.

#### KNITTING

Knitting is forming loops on a set of needles and pulling a thread through the loops.

#### BONDING

Fibres are bonded together by heating, gluing or stitching the fibres together. A bonded fabric has no weft or warp threads and no right or wrong side. They are usually inexpensive fabrics that do not fray, such as felt.

### Exam Questions

- 1.Name as many specific types of wool as possible and link them to the animal that produces the fibres that the wool is made from.
- 2.What properties of silk make it suitable for luxury items of clothing?
- 3.What might happen to woollen felted products if they are washed in hot water?

### Stretch

- A.Why are most synthetic fibres so water resistant and quick drying?
- B.Explain how a ladder is formed in a knitted garment.

### Further links

[www.bbc.co.uk/schools/gcsebit/eseize/design/textiles/](http://www.bbc.co.uk/schools/gcsebit/eseize/design/textiles/)



**Core principles:**  
Sustainability

Sustainability:

**Sustainable design** is the intention to reduce or completely eliminate negative **environmental** impacts through thoughtful designs.

But also social (people) and cultural issues.



Designers need to take responsibility for their designs and be more than just aware of the need to protect our environment and raw materials from being used up.

The Six Rs of sustainability help designers think about designs and designing in the following way:

**RETHINK** - our current lifestyles and the way we design and make.

**REFUSE** - to buy materials and products that are unsustainable.

**REDUCE** - the amount of energy and materials used to manufacture a product.

**REUSE** - the product for something else so you don't need to throw it away.

**REPAIR** - the product so you don't need to throw it away.

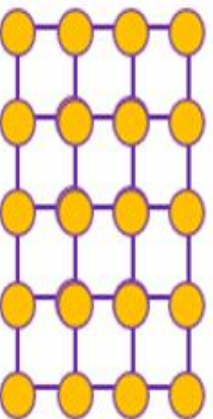
**RECYCLE** - finally take the product apart and categorise the parts ready for being converted into another product. This uses a lot of energy.

## Introduction

Plastics are mainly **synthetic materials** made from polymers traditionally derived from finite resources such as **coal, oil and gas**, but are increasingly being produced using **sustainable sources** such as **vegetable starches**. There are also naturally occurring plastics such as rubber. Use this sheet as a basis for revision and further research into plastics when preparing for your exam.

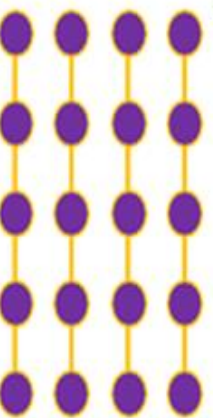
## Thermosetting plastics

Thermosets are more rigid and once they have been formed and set once, they are stuck in that shape forever. The polymer chains in thermosets have more 'cross links' between them which stops the plastic moving when heated. As a result, thermosets are more brittle and harder than thermoplastics. Thermosets have good resistance to heat and make good electrical insulators. They are however difficult to recycle as they burn rather than melt.



## Thermoplastics

Thermoplastics are the most common types of plastics we see **every day**. They are generally the **most flexible**, especially when heated. This is due to their physical structure. Their polymer chains (see below) are loose which means they can slide past each other when heated. This allows them to be **reformed multiple times**. Thermoplastics are usually **very easy to recycle** due to the fact they can be remoulded multiple times.



**PP**

**Polypropylene**

**Properties:** Flexible, Tough,

**Lightweight, Food safe**

**Common Uses:** Food containers, Stationary products, Kitchen products.



**HIPS**

**High Impact Polystyrene**

**Properties:** Flexible, Impact

**resistant, Lightweight, Food safe.**

**Common Uses:** Food containers, Household Electronic casings.



**HDPE**

**High Density Polyethylene**

**Properties:** Lightweight, Rip and

**Chemical resistant.**

**Common Uses:** Milk bottles, Pipes, Buckets, Bins, Household Bottles.



**LDPE**

**Low Density Polyethylene**

**Properties:** Very flexible, high strength to weight ratio.

**Common Uses:** Plastic bags, Piping, Plastic food wraps, Bottles.



**PET**

**Polyethylene Terephthalate**

**Properties:** Stable, easily blow moulded, resistant to chemicals, fully recyclable.

**Common Uses:** Bottles, Food Packaging



**ABS**

**Acrylonitrile Butadiene Styrene**

**Properties:** Hard, Tough, Rigid, High quality, Good insulator.

**Common Uses:** Children's toys, Electrical Casings, Car interiors.



**PVC**

**Polyvinyl Chloride**

**Properties:** Flexible, Tough,

**Chemical Resistant.**

**Common Uses:** Pipes, Electrical wire.



**PF**

**Phenol Formaldehyde/Bakelite**

**Properties:** Very rigid, Hard and Brittle.

**Common Uses:** Electrical components, Mechanical parts,

**Old clocks, phones and radios.**



**Polyester Resin**

**Polyester Resin**

**Properties:** Strong, Heat resistant,

**Good electrical insulator.**

**Common Uses:** Waterproof coatings, Flooring, Fiberglass lamination



**MF**

**Melamine Formaldehyde**

**Properties:** Lightweight, Hard,

**Brittle, Food Safe.**

**Common Uses:** Kitchenware, Heat Resistant surfaces, Furniture.



**ER**

**Epoxy Resin/Araldite**

**Properties:** Good strength to weight, Strong resin, Expensive, Heat

**resistant, Good electrical insulator.**

**Common Uses:** Bonding materials, PCBs, Waterproof coatings.



**Urea Formaldehyde**

**Urea Formaldehyde**

**Properties:** Heat resistant, Good electrical insulator, Hard, Brittle.

**Common Uses:** Electrical fittings, casings, Buttons and handles.

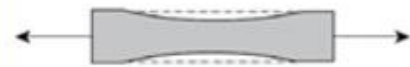


## 2. Forces and Stresses on Plastic Products

The products below are made from various plastics. In their everyday use, these products are regularly having forces applied to them. These forces affect the way the product operates and its overall function and safety. Designers and manufacturers need to ensure that the materials they select for their products are able to withstand the forces and stresses the product will be subjected to. If they get this wrong, it could have serious consequences.

### Types of Forces and stresses

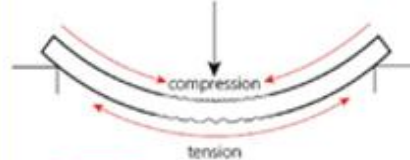
**Tension forces** are pulling forces that cause an object to be stretched or pulled apart.



**Bending forces** act at an angle to an object and make it bend.



When an object bends it is under **compression** and **tension** at the same time. See below...



**Compression forces** are pushing forces that squeeze an object. Imagine a 'crushing' motion.

**Shearing forces** act across a material by creating a shearing action. Scissors are a good example.



**Torsion forces** are twisting forces that are applied to an object.



# Specialist Technical Principles



## 3. Sources and Origins of Plastics

### Petrochemical Polymers

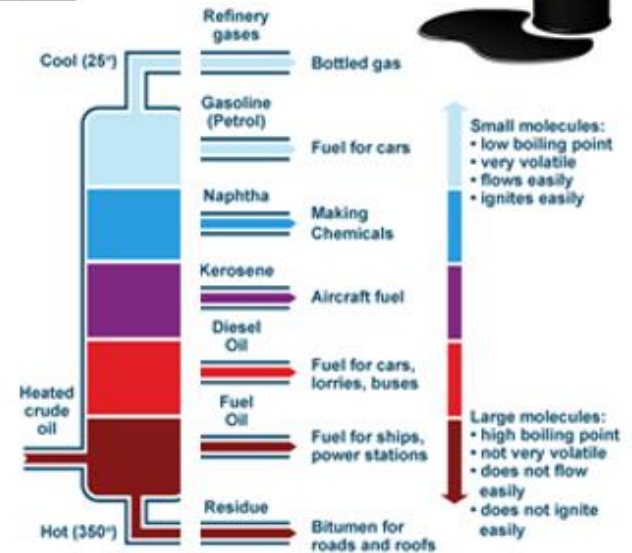


#### Fractional Distillation

Most plastics are created from Crude Oil.

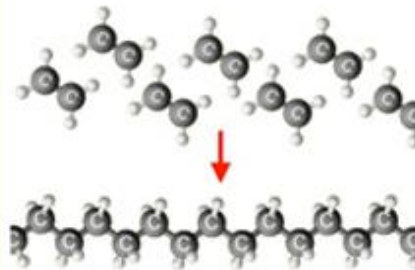
The production of plastic begins with a distillation process in an oil refinery.

The distillation process involves the separation of heavy crude oil into lighter groups called fractions. Each fraction is a mixture of chemical compounds made up of carbon and hydrogen (hydrocarbons), which differ in terms of the size and structure of their molecules. One of these fractions is called Naphtha which is the crucial element for the production of plastics.



#### Polymerization

The main process used to produce plastics is called **polymerization** which requires specific catalysts. In a polymerization reactor, monomers like ethylene and propylene are linked together to form long polymers chains (see below).



### biopolymers

Biopolymers are natural polymers which can be made from starchy vegetables such as corn or plants containing lots of fiber, fat or carbohydrate.

Biopolymers are **fully Biodegradable** when put into landfill. The natural bacteria in the soil helps break down the plastic very quickly due to being exposed to moisture and high temperatures.

Biopolymers are **non-toxic** and are made from renewable resources, therefore having a low environmental impact.

The most common Bioplastics that you should research are PLA (Polylactic Acid), PCL (Polycaprolactone) and PHB Polyhydroxy butyrate.

**Polymer origins and forces. Questions.** 1. How can a product be designed to resist forces better? 2. What forces could be exerted on a chair in normal use? 3. Our 3D printer filament is made of corn starch – how is this better for the environment? Is there a disadvantage

## 4. Ecological and Social Footprint

theguardian

A million bottles a minute: world's plastic binge 'as dangerous as climate change'

### Deep Reading

It is estimated that between 4 and 12 million metric tons of plastic makes its way into the ocean each year. This figure is only likely to rise, and a 2017 report predicted that by 2050 the amount of plastic in the sea will outweigh the amount of fish.

A normal plastic bottle takes about 450 years to break down completely, so the components of a bottle dropped in the ocean today could still be polluting the waters for our great-great-great-great-great-great-great-great-great-great-grandchildren.

We need to talk about plastic. A landmark study revealed that billions of people globally are drinking water contaminated by plastic particles. Almost 75% of tap water samples tested in the UK contained traces of plastic. Fish also ingest the small plastic pieces which then contaminates any seafood we eat.



A million plastic bottles are bought around the world every minute and the number will jump another 20% by 2021, creating an environmental crisis some say will be as serious as climate change.

The demand, equivalent to about 20,000 bottles being bought every second, is driven by a desire for bottled water and the spread of an 'on the go' culture around the world.

More than 480bn plastic drinking bottles were sold in 2016 across the world, up from about 300bn a decade ago. If placed end to end, they would extend more than halfway to the sun. By 2021 this will increase to 583.3bn, according to the most up-to-date estimates from Euromonitor International's global packaging trends report.

Most plastic bottles used for soft drinks and water are made from Polyethylene Terephthalate (PET), which is highly recyclable. But as their use soars across the globe, efforts to collect and recycle the bottles to keep them from polluting the oceans, are failing to keep up.

## The Sustainability of plastic products

### Deep Reading

Most plastics are made from Crude Oil (see above). Crude Oil is a Non-renewable/Finite resource which means that we will eventually run out of it. End of life considerations are also important for plastic products as most plastics take so long to decompose.

Many responsible companies produce a Product Life Cycle Assessment which informs them of the environmental impact there products will have. The information they gather helps them decide how best to source, manufacture and dispose of their products to limit their environmental impact.

Extracting Crude Oil uses extremely high levels of energy which is created by burning fossil fuels. These fossil fuels release high amounts of CO<sub>2</sub> into the earth's atmosphere which contributes to Global Warming.

The situation is similar when manufacturing plastic products. The polymers need to be heated to high temperatures in order to mold them. This is again achieved by burning fossil fuels, which releases more CO<sub>2</sub>, and contributes to Global Warming.

At the end of a plastic product's life there are several options to consider. Firstly, plastic products can be reused as they're typically easy to repair and maintain which means they can survive longer than wooden or metal based products.

Most plastics are also recyclable, this means the material can be melted down and then put back into production to become a new product. This saves the material from ending up in landfill and also prevents us from sourcing more plastics from crude oil.

The final option is to throw the product into Landfill. This causes significant environmental issues as plastics take hundreds of years to decompose and since the material hasn't been recycled, we must then create new plastic products using more crude oil, putting even more strain on the planet's non-renewable resources.

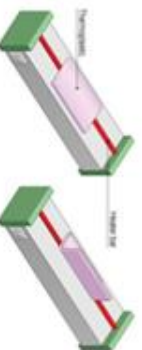




## De-Forming and Reforming Plastics

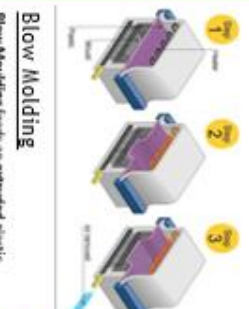
### Line Bending

Strip heaters are a good way to create a permanent fold in Thermoplastics such as acrylic. You start by marking on the plastic using a marker. You place the marking over the heated wire and wait the allocated time (depending on thickness of material). Once removed, the plastic should be bent around a jig to ensure accuracy and so any additional products are identical.



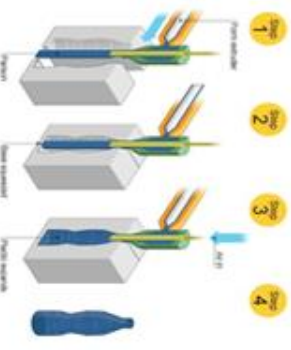
### Vacuum Forming

Vacuum Formed products include plastic 550 boxes, bath-lids, buckets and yoghurt pots. A sheet of Thermoplastic is heated and pressed onto the former (mold) by an atmospheric pressure. The vacuum sucks the plastic over the top of the former to take the shape. The former must be removed after this process, therefore the shape of the former must be tapered to allow it to slide back out.



### Blow Molding

Blow Moulding feeds an extruded plastic tube known as a parison into a hollow mold such as the mold for a bottle. The parison is pinched at the bottom as the mold closes and filled with heated compressed air until the parison inflates to fill the mold. The plastic cools and is trimmed once it has been removed from the mold.



### Extrusion

Extrusion is used to create a continuous flow of plastic which is pushed through a die to create a specific shape. Extrusion is used for cables, pipes, PPS/PVDF, and even plastic film.

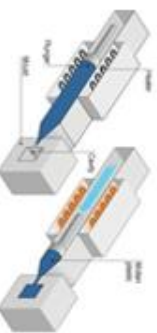
The extrusion process works similar to injection moulding except extrusion is continuous whereas injection moulding uses a hydraulic press to push specific amounts of plastic into a mould.



### Injection Moulding

This process is ideal for complex shapes. Firstly a mould is made; there are generally constructed from steel in two parts. They need to be very accurate as any blemishes will be transferred to every item produced.

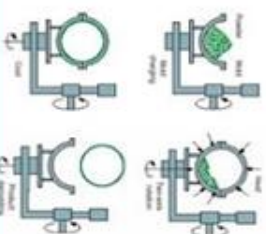
Injection moulding is used for intricate plastic components such as bottle tops, casings with clips and internal components of electrical products. Injection moulding works by melting plastic in a chamber and using a hydraulic press to push the molten plastic into the mould.



### Rotational Moulding

Rotational Moulding is a process that is ideal for the manufacture of hollow products. These include tanks holding liquids such as rainwater tanks and waste disposal containers, footballs, road cones, forklifts and luggage trays. Polyethylene and Polypropylene are ideal polymers for this moulding process. It is particularly suitable for the manufacture of batches from 100 to 5000 units.

The mould opens and is filled with powdered polyethylene or polypropylene and closed. The mould is heated to 300°C. At the same time the mould rotates so that the powder is forced against the wall of the mould. The mould then cools slowly and solidifies.



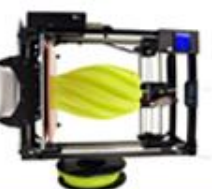
## Forming Polymers

- Questions.**
1. Explain in detail how a 3D printer works. How would you alter your design to make the printing easier or better quality?
  2. What is the difference between injection moulding and extrusion? Give examples of products made in these ways to help you explain.
  3. with a strip heater, how can you ensure accurate, good quality work? Give three safety precautions you could take when using this machine.

## 3D Printing

3D Printing allows physical objects to be formed from reels of Thermoplastic. 3D Printers also use CAD files and coordinates the printer to follow the design by building up layers.

3D Printers are commonly used for Rapid Prototyping. This means that designers can model their designs from the actual material they will be made from, without having to pay lots of money for models to be made for processes such as injection moulding. 3D Printing is unsuitable for large scale production due to the speed in which it makes products and components.



## Addition & Joining Methods

### Laminating

Laminating involves bonding strips or sheets of material together in layers. It can be done with thick materials to create very strong structures or very thin materials to create tough and flexible products.

Plastics are often laminated with other materials such as woods and glass to improve aesthetics and functionally.

Laminated safety glass is now used in car windcreens. The sheet of plastic sits between the front and back layer of the windscreen preventing it from falling through in the event of a crack or smash.



### Welding Plastics

Plastics can be welded using either heat or chemicals. A chemical weld is the most common in schools by using either Liquid Solvent Cement or Tensol 12.

Both substances dissolve the surface of the plastics being joined. Heat welding plastic involves using a special hot air gun which accurately heats the areas being welded together as well as a plastic filler rod that is applied to the weld joint.



### Plastic Rivets

Small plastic rivets which can be used as a quick and cheap alternative to screws and nuts for holding plastic components together. Some rivets come in two parts, the head and sleeve. The sleeve pushes through holes in the items to be attached, and the pin is pushed into the sleeve. The insertion of the pin makes the sides of the sleeve splay out, providing a secure grip.



### Heat Sealing

Heat sealers (also known as bag sealers) are machines that are used to seal various thermoplastics and are available in a range of different sizes. The sealers are ideal for use on plastic tubing as they close off the edges, ensuring that it protects the content inside. Heat sealing is used to make packaging safe to help preserve products for longer.



## 6. Using and Working with Materials

### Drilling, Cutting and Abrading

#### Drilling:

**Pillar Drill** – Drilling a hole into plastic requires careful speed and control. Drilling a pilot hole before drilling larger holes is strongly advised. Too much pressure can cause the plastic to crack. A pillar drill is good for accuracy and is powerful enough to drill large holes in thicker materials.



#### Cutting:

**Coping Saw** – A coping saw is used to cut curved lines in thinner materials. The thin blade allows the user to follow a detailed path in order to cut complex shapes.



**Scroll Saw/Band Saw** – The Scroll Saw and Band Saw are both powered and can be used for cutting straight and curved lines. They can overheat and melt which clips the blade.

**Vinyl Cutter** – The computer controls the movement of a sharp blade. This blade is used to cut out shapes and letters from sheets of thin self-adhesive plastic (vinyl).



**Laser Cutter** – One of the most accurate ways to cut plastics. The laser itself can follow a design generated on a **CAD (Computer Aided Design)** program to a very fine tolerance however, Laser Cutters must be setup properly considering the following:

- Kerf Allowance
- Power and Speed Settings
- Focusing the Beam
- Clean Mirror and Lenses

#### Abrading:

**Filing** – Metal files can be used to smooth the edges of plastics. Different shaped profiles and grades of cut are available for various tasks.

**Wet and Dry Paper** – Paper backed abrasive material used to clean up and smooth surfaces. Can be used either wet or dry. Different grades are available from 150 to 2000.

The latter is so fine it has a polishing effect.  
**Abrasive Pads** – Similar to abrasive paper, removes small surface scratches ready to be polished.



### 7. Stock forms

| Stock Form      | Description   | Image |
|-----------------|---|-------|
| Sheet           | Metric is the standard size for measuring plastic forms. Sheet starts at 1mm thick. Sheet is commonly used when line Bending, Vacuum Forming and Laser Cutting. |       |
| Rod             | Rod is available from 2mm to well over 100mm diameter. Rod is commonly used in plastic fixings as well as other plastic components.                             |       |
| Tube            | Tube is usually available from 5mm to around 1 <u>metre</u> in diameter. You also need to decide on the wall thickness. Tube is commonly used in piping.        |       |
| Powder/Granules | Powders and Granules are commonly used for Plastic Dip Coating, Injection Moulding and Extrusion  |       |
| Foam/Film       | Foam and Film is commonly used in food packaging. Foam is incredibly lightweight is good for cushioning.  |       |

### 8. Scales of Production

#### One Off Production

In one-off production a single product is designed and made to a client's specification. Labour and material costs are high, and a high level of design and manufacturing skills are needed. Pieces of art are often one-off.



#### Batch Production

In batch production set quantities of a product are made to order. Materials are cost-effective and manufacturing costs are lower. Items that go out of fashion relatively quickly are usually Batch produced.



#### Mass Production

Mass production is the industrial scale manufacture of large quantities of products, usually on a production line. Standardised production methods mean it is suitable for products that are not redesigned very often.



#### Continuous Production

Continuous production is the manufacture of an item 24/7 – 365. The system is usually completely automated using a production line. Due to the scale on which the items are manufactured, they are extremely cost effective.



**Questions.** 1. What stock form of acrylic do we use in a Laser cutter? 2. What is the difference between a scroll saw and a tenon saw in terms cutting material? 3. Compare and contrast two types of scale of production, using product examples to help you. 4. Explain what abrading is, using examples of their appropriate use.

## 9. Surface Treatments and Finishes

| Name                                  | Image   | Description  | Name  | Image   | Description  |
|---------------------------------------|---|--|---|---|--|
| Painting<br>Spray Primer<br>and Paint |    | Used for aesthetics, UV protection and Priming surfaces.           | Heat Transfer<br>Printing                       |    | Printed and transferred onto a surface with a heat press.        |
| Vinyl Decals                          |    | Printed & cut self-adhesive vinyl, used for high quality graphics. | Hydro<br>Graphic<br>Printing                    |    | Printed on water soluble film which floats. Object is submerged. |
| Flocking                              |   | Fluffy finish created through static charge.                       | Electroplating<br>and<br>Electroless<br>Plating |   | Plated with nickel, chrome, copper, tin or gold.                 |
| Embossing<br>and<br>Engraving         |  | To raise or lower the material in order to enhance text.           | Rubberising<br>Spray                            |  | Slightly textured coating for grip. Has a matt finish.           |

**Questions.** 1. What is the advantage of using CAD to manufacture a vinyl sticker?

2. One of the advantages of polymers is that they are self finishing surfaces, often needing no further treatment. Explain two examples where this may not be the case.