SPRING TERM

- Group Design & Make – Mechanical Toys
- Smart and Modern Materials

YEAR 10 - SPRING	REVISION TOPICS

- Types of motion
- Mechanical Devices
  - Levers
  - Pulleys
  - Gears
  - Cams
- Energy Generation
- Energy Sources
  - Renewable
  - Non Renewable
- Timber – Trees to Timber
- Timber Life Cycle
- Material Properties
- Metals – Categories
- Metal – Specific materials (properties & uses)
- Smart Materials – Stimuli
- Smart/Modern Materials – Specific materials (properties & uses)

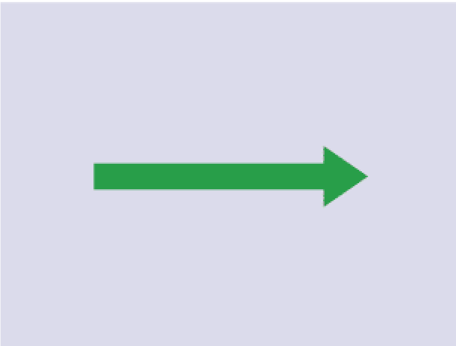
KEY QUESTIONS

1. WHAT ARE THE DIFFERENT TYPES OF MOTION?
2. WHAT ARE SOME COMMON EXAMPLES WHERE YOU CAN SEE THE DIFFERENT TYPES OF MOTION?

YEAR 10 – SPRING

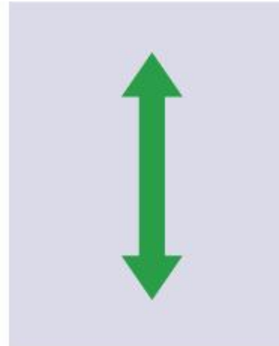
TYPE OF MOTION

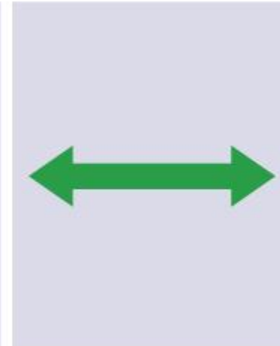
Linear motion moves something in a straight line, eg a train moving down a track:



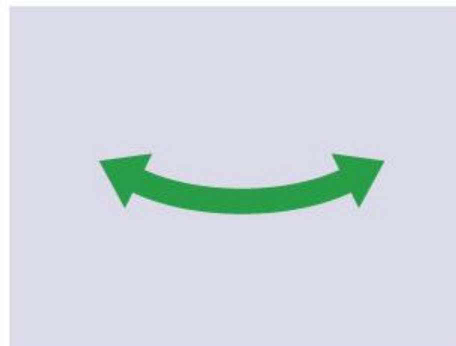
Rotary motion is where something moves around an axis or pivot point, eg a wheel:

Reciprocating motion has a repeated up and down motion or back-and-forth motion, eg a piston or pump:





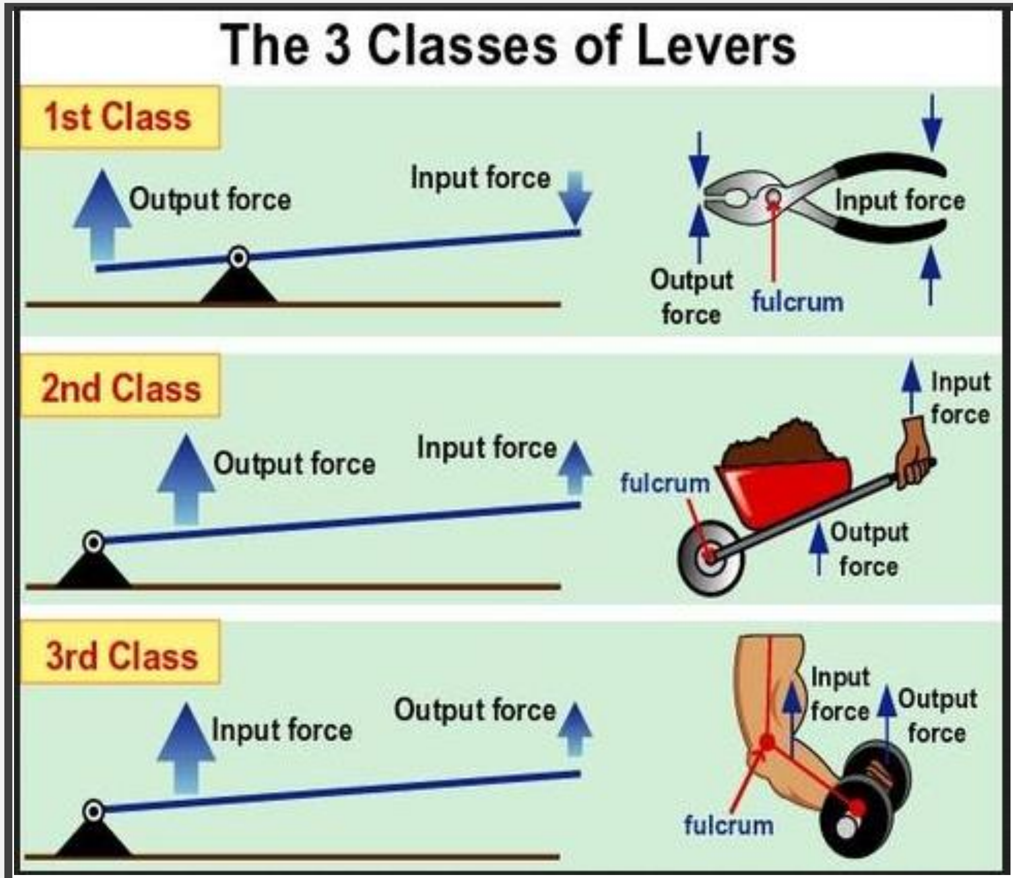
Oscillating motion has a curved backwards and forwards movement that swings on an axis or pivot point, eg a swing or a clock pendulum:

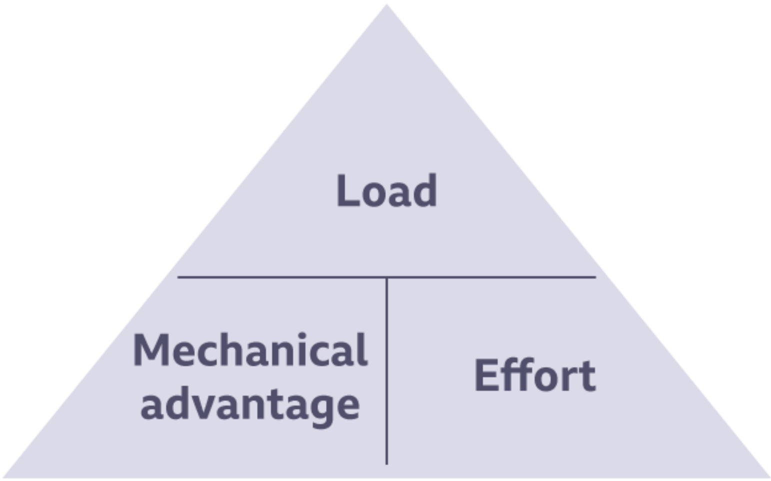


KEY QUESTIONS

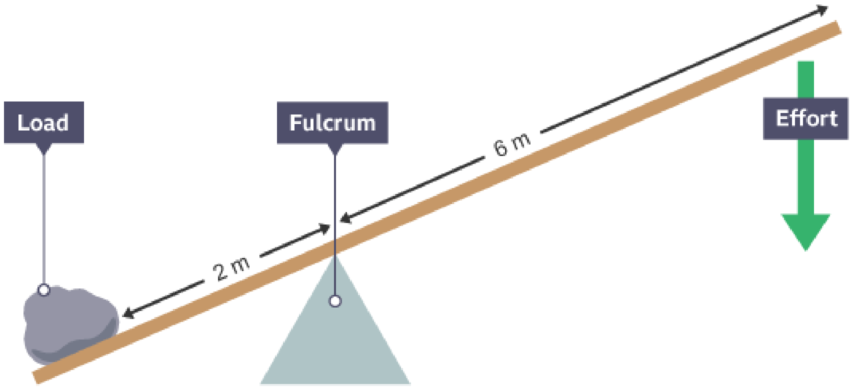
1. WHAT ARE THE DIFFERENT CLASSES OF LEVER?
2. WHAT ARE SOME COMMON APPLICATIONS FOR EACH CLASS OF LEVER?
3. HOW DO YOU CALCULATE THE MECHANICAL ADVANTAGE OF A LEVER?

YEAR 10 – SPRING | MECHANICAL DEVICES - LEVERS





- mechanical advantage = load ÷ effort
- load = mechanical advantage × effort
- effort = load ÷ mechanical advantage



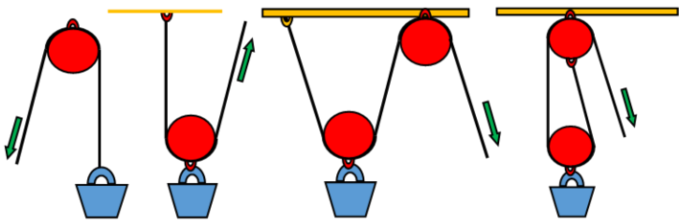
Therefore, the mechanical advantage = 6 ÷ 2 = **3** or **3:1**

KEY QUESTIONS

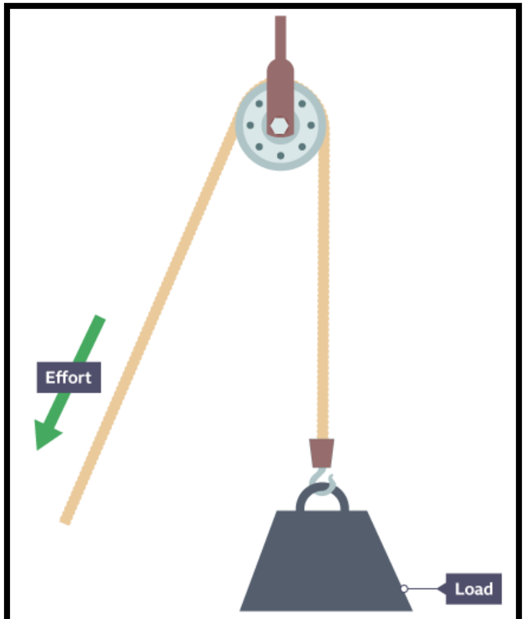
1. WHAT ARE THE DIFFERENT CONFIGURATIONS OF PULLEYS
2. WHAT ARE SOME COMMON APPLICATIONS OF PULLEYS?
3. HOW DO YOU CALCULATE THE MECHANICAL ADVANTAGE OF A PULLEY?

MECHANICAL DEVICES - PULLEYS

Types of Pulleys

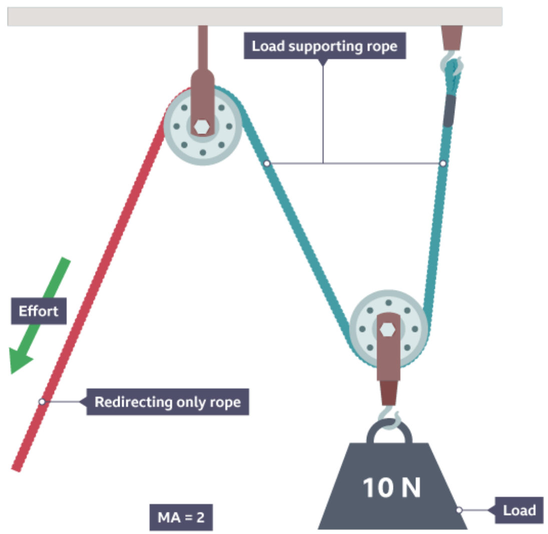


Fixed	Moveable	Compound	Block & Tackle



A single fixed pulley has a mechanical advantage of one

The 10 N load below would require half of the force to lift. There are two sections of rope taking the strain, so 5 N of force would be needed to lift it. The mechanical advantage would be 2.



The mechanical advantage is equal to the number of sections of rope pulling up on the object.

Belts can be attached around different-sized pulleys to drive shafts to change speed. As with gears, the bigger the wheel, the slower the speed. The **velocity ratio** between two pulleys can be calculated.

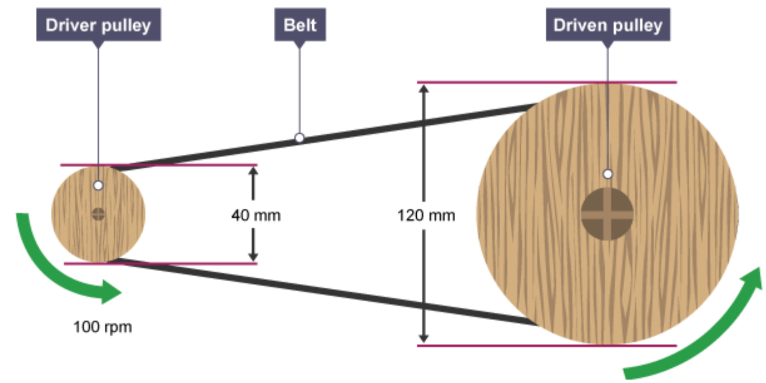
Velocity ratio = diameter of the driven pulley ÷ diameter of the driver pulley

This can then be used to calculate the output speed.

Output speed = input speed ÷ velocity ratio

Example

A driven pulley has a diameter of 120 mm and a driver pulley has a diameter of 40 mm.



Velocity ratio = diameter of the driven pulley ÷ diameter of the driver pulley

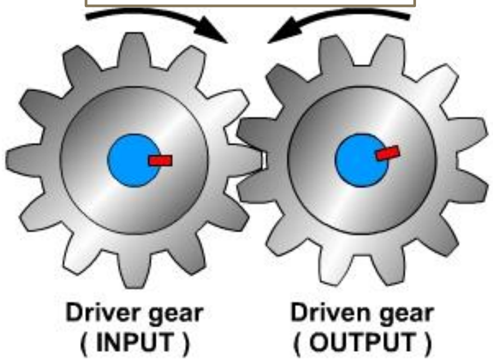
= 120 ÷ 40 = **3** or **3:1**

KEY QUESTIONS

1. WHAT ARE THE DIFFERENT TYPES OF GEARS?
2. WHAT ARE SOME COMMON APPLICATIONS OF GEARS?
3. WHAT ARE THE DIFFERENT WAYS GEARS CAN TRANSFER/TRANSFORM MOTION?

YEAR 10 – SPRING | MECHANICAL DEVICES - GEARS

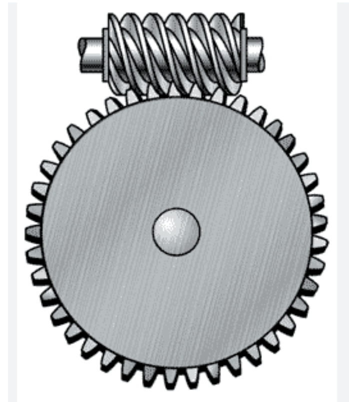
Spur Gears



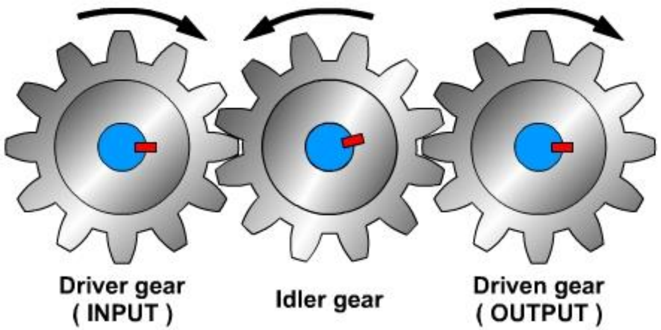
$$\text{Velocity ratio} = \frac{\text{distance moved by the effort (driver gear}}{\text{distance moved by load (driven gear)}}$$

$$\text{Velocity ratio} = \frac{\text{number of teeth on the driven gear}}{\text{number of teeth on the driver gear}}$$

Worm Gears



Rack and Pinion



Idler Gears

Bevel Gears

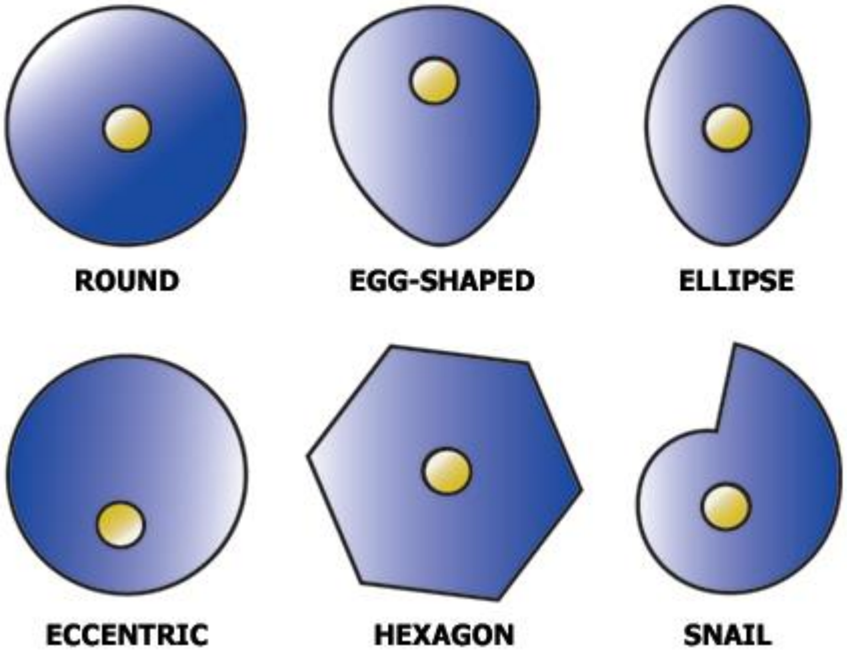
Application of Different Types of Gears

Gearboxes, which are devices made up of gears housed within an enclosure or housing, are one of the most common applications for gears. These devices use a variety of gear types, such as worm gears, bevel gears, helical gears, and spur gears, and are designed to perform a specific motion or power transmission operation inside the machine system, such as altering the speed and torque or changing the direction of the output shaft.

Gearboxes, like most gear systems, have a range of applications, such as Conveyors, Agitators, Ball Mills, etc.

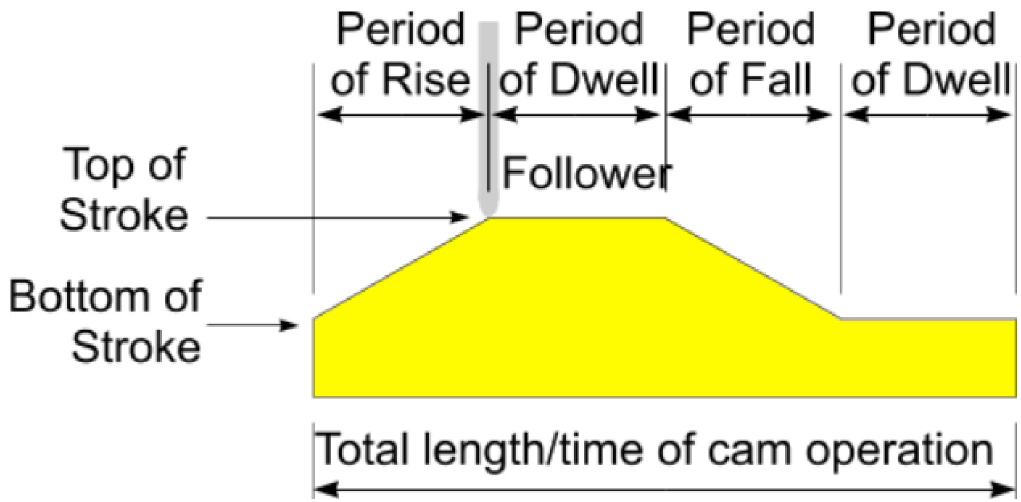
KEY QUESTIONS

1. WHAT ARE THE DIFFERENT TYPES OF CAMS?
2. WHAT ARE SOME COMMON APPLICATIONS OF CAMS? HOW DO THEY TRANSFORM MOTION?
3. HOW CAN YOU REPRESENT THE “FOLLOWER MOTION” OVER TIME?



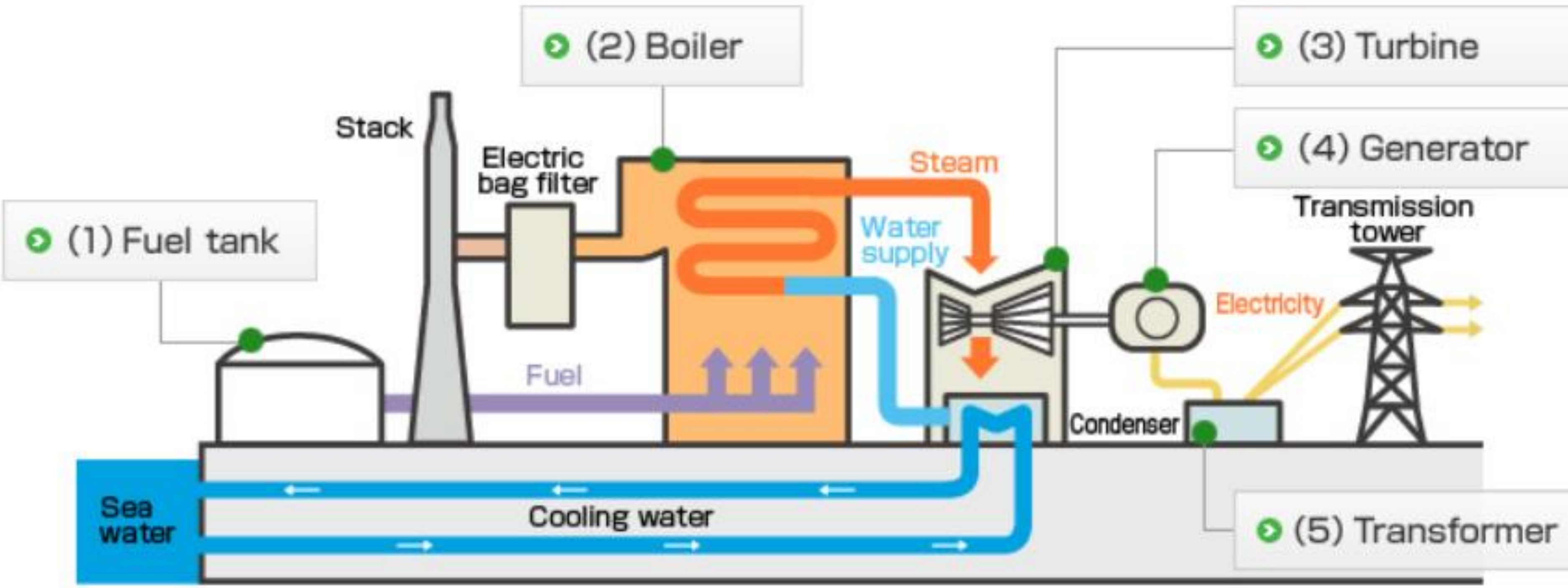
Cams are used in a number of different applications both in industry. and everyday objects, some of the most common are:

Door lock mechanisms
Stamping machines
Vehicle transmission
Hammering machines
Sewing machines
Dishwashers
Washing machines
Reciprocating saws
Sequential transmission



KEY QUESTIONS

1. HOW IS ELECTRICITY GENERATED?


(1) Fuel tank
Stack
Electric bag filter
(2) Boiler
Steam
Water supply
(3) Turbine
(4) Generator
Transmission tower
Electricity
Fuel
Condenser
(5) Transformer
Sea water
Cooling water

KEY QUESTIONS

1. WHAT ARE THE DIFFERENT FINITE (NON RENEWABLE) SOURCES USED TO GENERATE ELECTRICITY?
2. WHAT ARE THE ADVANTAGES OF FINITE ENERGY SOURCES?
3. WHAT ARE THE DISADVANTAGES OF FINITE ENERGY SOURCES?

Coal

- Comes from the remains of plants that died hundreds of millions of years ago
- Has the highest level of carbon of all fossil fuels

Oil

- Comes from the remains of plants that died hundreds of millions of years ago
- Can be extracted and refined to make gasoline, diesel and jet fuel

Natural Gas

- Formed from the remains of tiny sea plants and animals that died millions of years ago
- Mainly composed of methane

Nuclear Energy

- Energy released when atoms' nuclei are fused together (fusion) or split apart (fission)
- Nuclear power plants produce electricity through nuclear fission

KEY QUESTIONS

1. WHAT DIFFERENT METHODS ARE THERE FOR GENERATING ELECTRICAL ENERGY FROM RENEWABLE SOURCES?
2. WHAT ARE THE ADVANTAGES OF RENEWABLE ENERGY SOURCES?
3. WHAT ARE THE DISADVANTAGES OF RENEWABLE ENERGY SOURCES?

YEAR 10 – SPRING | ENERGY GENERATION - RENEWABLES

Wind Energy

- Energy in moving air, harnessed by wind turbines
- Used to produce electricity

Solar Energy

- Energy that comes from the sun
- Converted into heat, light and electricity

Hydropower

- Energy in the force of moving water
- Captured by dams in hydropower plants and converted to electricity

Biomass

- Energy contained in organic matter
- Used to generate electricity

Geothermal Energy

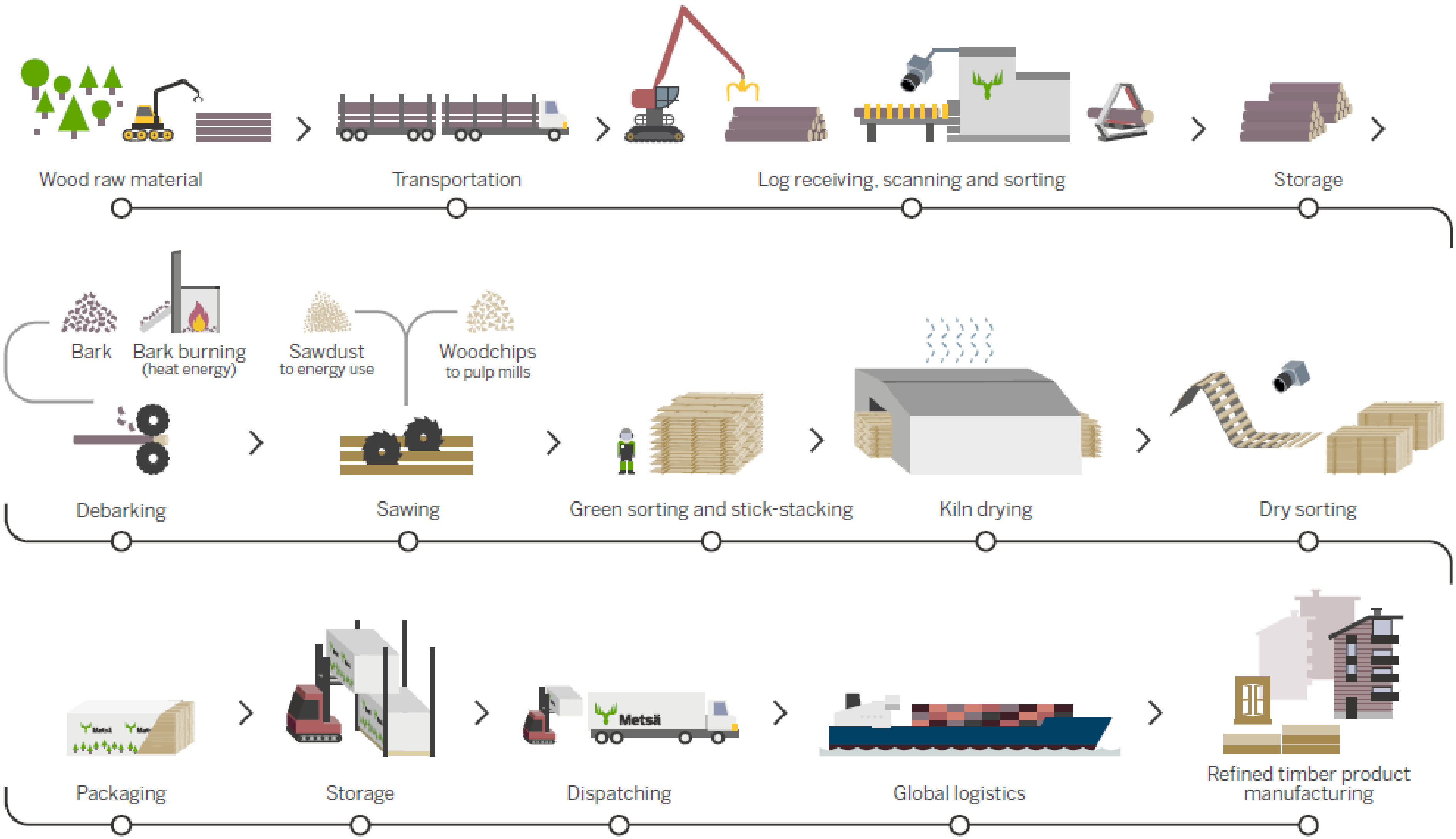
- Energy that comes from heat generated by the Earth
- Used to produce electricity and can provide heat and hot water

KEY QUESTIONS

1. WHAT IS THE PROCESS USED TO TRANSFORM TREES INTO A RAW MATERIAL FOR MANUFACTURING?

YEAR 10 – SPRING

TIMBER – MATERIAL PRODUCTION



KEY QUESTIONS

1. WHAT ARE THE ETHICAL AND SOCIAL CONSIDERATIONS OF USING TIMBER?
2. WHAT ARE THE ENVIRONMENTAL IMPACTS OF USING TIMBER?

Social and ecological issues

When considering the ecological and social implications of using timber, the term **'deforestation'** is often used. Deforestation is when a **clearing** is made by chopping down trees. This can often bring jobs and money into a local area but can also push out communities and wildlife. Without responsible management of deforestation, accompanying environmental issues can occur, such as:

•soil **erosion** that can lead to landslides

•an increase in global warming

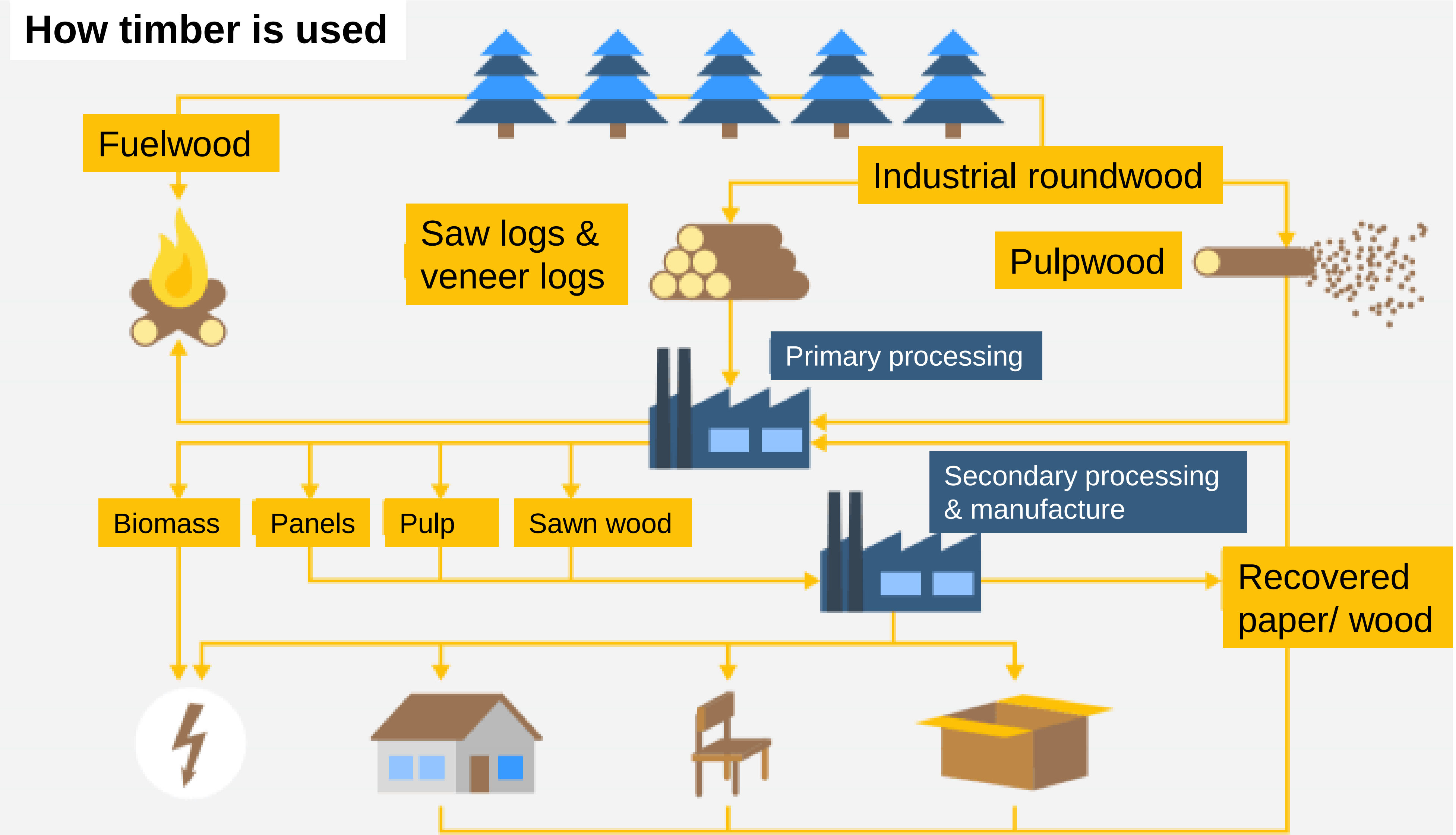
If more trees are planted than are cut, it is possible to minimise the environmental impact. Hardwood trees take a long time to grow in comparison to softwood trees so are more commonly planted in managed forests.

Supply and demand can cause issues for forest management. If the customer demands more timber due to an increase in purchasing, a forest management organisation could struggle as trees will take time to mature.

KEY QUESTIONS

1. WHAT IS THE LIFE CYCLE OF TIMBER?
2. WHAT ARE THE FOUR OUTPUTS FROM THE TIMBER LIFE CYCLE?

How timber is used



KEY QUESTIONS

1. WHAT ARE THE MOST COMMON ADJECTIVES USED TO DESCRIBE MATERIAL PROPERTIES?
2. WHAT IS THE DIFFERENCE BETWEEN PHYSICAL AND WORKING PROPERTIES OF MATERIALS?

YEAR 10 – SPRING

DESCRIBING MATERIALS

Physical properties are the traits a material has before it is used.

Physical properties:

- **absorbency** - the ability to soak up moisture, light or heat, eg natural materials (such as cotton or paper) tend to be more absorbent than man-made materials (such as acrylic or polystyrene)
- **density** - how solid a material is. This is measured by dividing mass (grams) by volume (cm^3), eg lead is a dense material
- **fusibility** - the ability of a material to be heated and joined to another material when cooled, eg webbing is fusible and can be ironed onto fabrics
- **electrical conductivity** - the ability to conduct electricity, eg copper is a good conductor of electricity
- **thermal conductivity** - the ability to conduct heat, eg steel is a good heat conductor, whereas pine is not

Working properties are how a material behaves when it is manipulated.

Working properties:

- **strength** - the ability of a material to withstand compression, tension and shear, eg in woven fabrics cotton isn't as strong as wool when pulled
- **hardness** - the ability to withstand impact without damage, eg pine is easier to dent with an impact than oak; therefore, oak is harder
- **toughness** - materials that are hard to break or snap are tough and can absorb shock, eg Kevlar in bulletproof vests is a very tough material
- **malleability** - being able to bend or shape easily would make a material easily malleable, eg sheet metal such as steel or silver is malleable and can be hammered into shape
- **ductility** - materials that can be stretched are ductile, eg pulling copper into wire shows it is ductile
- **elasticity** - the ability to be stretched and then return to its original shape, eg elastane in swimming costumes is a highly elastic material

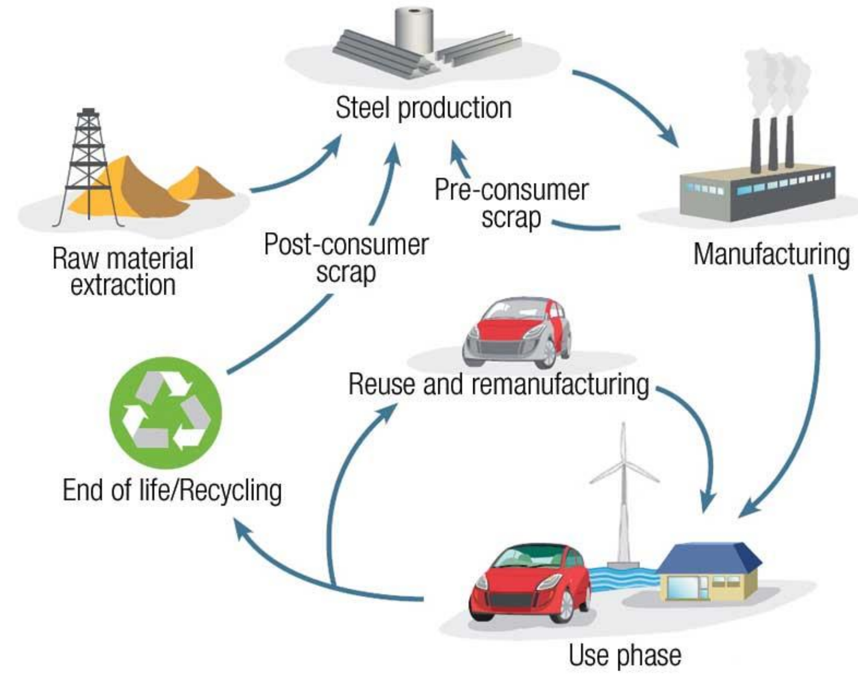
KEY QUESTIONS

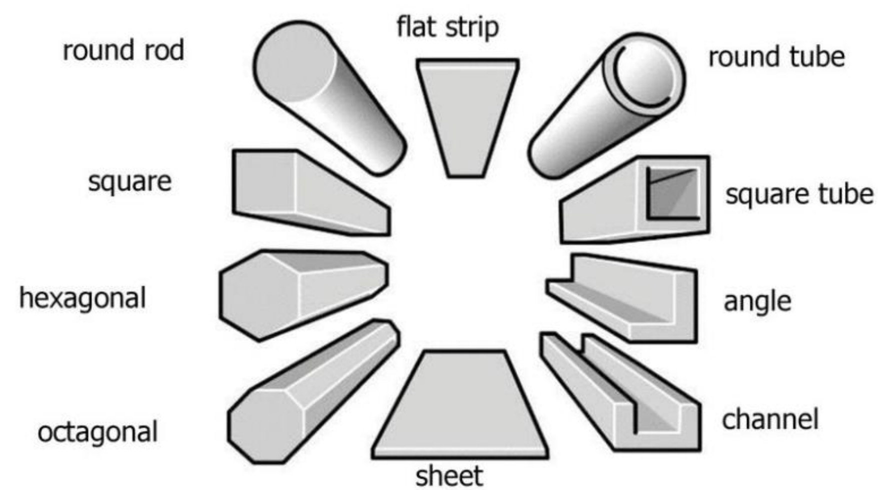
1. WHAT ARE THE THREE COMMON CATEGORIES OF METAL BASED MATERIALS?
2. WHAT ARE THE PRIMARY DIFFERENCES BETWEEN THE THREE MAIN CATEGORIES?
3. WHAT ARE SOME COMMON STOCK FORMS FOR METAL BASED MATERIALS?

YEAR 10 – SPRING

METAL - CATEGORIES

- Metals
  - Ferrous
    - Mild Steel
    - Tool Steel
    - Stainless Steel
    - Cast Iron
  - Non Ferrous
    - Aluminium
    - Brass
    - Copper
    - Lead
  - Alloys
    - Aluminium Alloys
    - Solder





KEY QUESTIONS

1. WHAT ARE THE NAMES OF SOME COMMON FERROUS METALS?
2. WHAT ARE SOME COMMON USES FOR THESE METALS?

FERROUS METALS CONTAIN IRON AND ARE **MAGNETIC**. THEY ARE PRONE TO **RUST**.

Ferrous metal	Physical properties	Working properties
Low-carbon steel (mild steel)	An alloy that is grey and smooth, rusts if not protected	Ductile and tough, easy to form, braze and weld, versatile, useful for construction, nuts, bolts, bike frames
Cast iron	Dull grey, rusts easily	Brittle if thin, can be cast in a mould, used for manhole covers, pans and gates
High-carbon steel (tool steel)	An alloy that is grey, smooth and does not rust easily	Hard-wearing, harder than low-carbon steel so less ductile but good for making tools, sharpens well

KEY QUESTIONS

1. WHAT ARE THE NAMES OF SOME COMMON NON FERROUS METALS?
2. WHAT ARE SOME COMMON USES FOR THESE METALS?

NON-FERROUS METALS **DO NOT** CONTAIN IRON AND ARE **NOT MAGNETIC**. THEY DO NOT RUST.

Non-ferrous metal	Physical properties	Working properties
Aluminium	Light grey with a matt finish	Lightweight but strong and ductile, used for drink cans, kitchen utensils and some parts in transport
Copper	Rose coloured, polishes well but can oxidise to a green colour (Verdigris)	Good electrical conductor, can be polished, welds easily, used for plumbing parts and electrical cable
Tin	Silver coloured	Soft and malleable, easy to form, used to make food cans
Zinc	Silvery blue with a matt finish	Brittle with average malleability and conductivity, often used to galvanise steel

KEY QUESTIONS

1. WHAT ARE THE NAMES OF SOME COMMON METAL ALLOYS?
2. WHAT ARE SOME COMMON USES FOR THESE METALS?

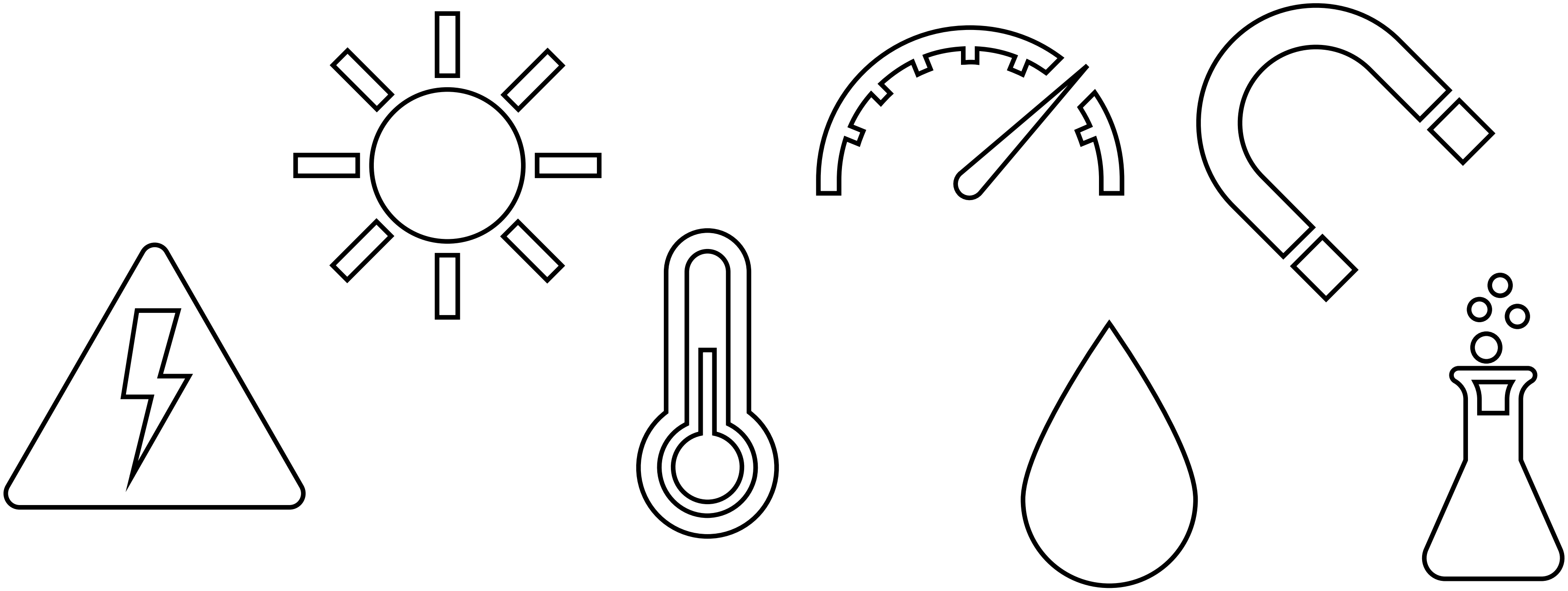
ALLOYS ARE MIXTURES OF METAL WITH AN ELEMENT TO IMPROVE ITS PROPERTIES OR **AESTHETIC**. FOR EXAMPLE BRASS IS A MIXTURE OF COPPER AND ZINC. ALLOYS CAN ALSO BE CLASSIFIED AS FERROUS OR NON-FERROUS.

Alloy	Physical properties	Working properties
Brass	Non-ferrous metal that is gold coloured and darkens when oxidised with age	An alloy of copper and zinc, can be cast and machined, used for musical instruments and ornamental hardware
Stainless steel	Ferrous metal that is silver when polished, resists rust	An alloy of chromium, nickel and manganese, hard and smooth, used for cutlery and sinks
High-speed steel	Ferrous metal is dark grey when used for tool bits	Can be alloyed with a variety of materials for different properties, can withstand high temperatures, used for drill bits and saw blades

KEY QUESTIONS

1. WHAT ARE THE COMMON STIMULI THAT CAUSE SMART MATERIALS TO REACT AND CHANGE?
2. WHAT IS THE BEST WAY TO DESCRIBE THE CHANGE IN A SMART MATERIAL?

YEAR 10 – SPRING | SMART MATERIALS – STIMULI



WHAT ARE SMART MATERIALS?

Smart materials are materials that are **manipulated to respond in a controllable and reversible way, modifying some of their properties as a result of external stimuli** such as certain mechanical stress or a certain temperature, among others. Because of their responsiveness, smart materials are also known as responsive materials. These are usually translated as "active" materials although it would be more accurate to say "reactive" materials.

KEY QUESTIONS

1. WHAT STIMULI PROMPT THE MATERIALS TO CHANGE?
2. WHAT CHANGES OCCUR?
3. HOW ARE THESE MATERIALS USED?

Shape-memory alloys (SMA) are metal **alloys** that can remember their shape when heated. These alloys have been utilised on spectacle frames that spring back to shape if they are squashed.

Nickel titanium (**nitinol**) is a type of SMA, and it contracts when heated, whereas most metals expand. When braces are made from nitinol, they heat up in the mouth and 'pull' on the teeth, so they move with the nitinol.

Setting SMA into the desired shape

Step 1: Fix SMA into the shape you want – use metal mechanical fixings

Step 2: Heat it up to 400 degrees for 8-10min

Step 3: Quench in cold water

KEY QUESTIONS

1. WHAT ARE THE PROPERTIES OF EACH MATERIAL?
2. WHAT ARE THE COMMON APPLICATIONS FOR EACH MATERIAL?

Gore-Tex fabric

Properties:

- Waterproof
- Breathable (allows moisture out)
- Holes on fabric allow sweat out, but not rain in
- Can be combined well with insulation fabric (to keep you warm)

Kevlar fabric

Properties:

- Eight times stronger than steel wire
- Does not melt and can withstand up to 450c
- Can withstand very low temperatures :- 96c
- Resistant to many chemicals
- Very lightweight

Nomex fabric

Properties:
- Thickens when heated, offering more protection
- Flexible fabric
- Lightweight
- Flame resistant
- Breathable (allows moisture)
- Durable (hard wearing)
- Abrasion resistant (does not get worn out easily)

X-Static fabric

Properties:
- Anti odour (Does not hold smell)
- Made with pure silver
- Very flexible
- Soft
- Long lasting
- Stretchy
- The silver reacts with bacteria
- Has been proven to eliminate 99% bacteria within one hour

Shape memory alloys

Properties:

- If the material is bent or de-formed, it returns to its set shape when heated up
- Can come in a variety of thick-nesses
- Possibility to blend into fabrics

Thermochromic dyes

Properties:

- Can dye a fabric any colour
- The colour changes when heat or UV light reacts with the fabric
- The colour can change on a scale, depending on temperature or light(For example the colour may go more vibrant as the material is heated up more)

Microfibre fabric

Properties:
- Breathable (let sweat out)
- Durable (does not get worn out easily)
- Crease resistant
- Some variations can hold chemicals such as deodorants, insecticides and perfumes that are released when worn

Coolmax fabric

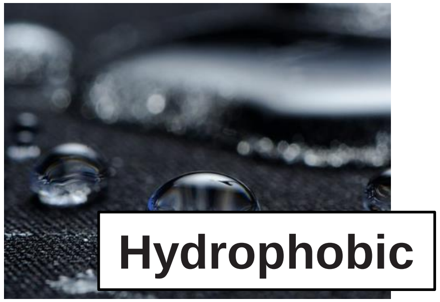
Properties:
- Draws sweat from the skin
- The fabric dries quickly
- Breathable (Lets sweat out)
- Soft
- Comfortable
- Holds its shape

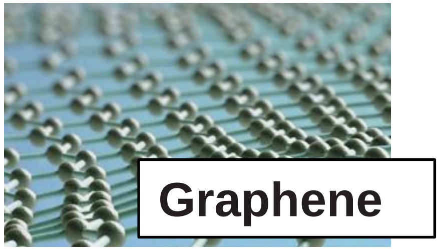
KEY QUESTIONS

1. WHAT ARE THE PROPERTIES OF EACH MATERIAL?
2. WHAT ARE THE COMMON APPLICATIONS FOR EACH MATERIAL?

YEAR 10 – SPRING

COMPOSITES AND HIGH PERFORMANCE





Composites

Fibre-based composite	Materials	Uses
Glass-reinforced plastic (GRP)	Glass fibres and resin	Boats, instrument cases
Carbon-reinforced plastic (CRP)	Carbon fibre and resin	Formula 1 car bodies, crash helmets, sports equipment
Glass-reinforced concrete (GRC)	Glass fibre and concrete	Street furniture, urban features

Particle-based composite	Materials	Uses
Concrete	Cement, sand and aggregate	Buildings, street furniture
Cermet	Ceramic (cer) and metal (met)	Electronic components that need to operate under very hot temperatures