Year 11 Knowledge organiser— ENERGY GENERATION

Without energy most of the things we do would be impossible. Over the last 100 years we have become increasingly dependent on electricity and the energy sources that we rely on to provide it.

Fossil Fuels

Fossil fuels include coal, gas and oil to provide energy. The resources are known as finite resources, meaning that they will eventually run out, and won't be able to provide for future generations.

All fossil fuels have to be burnt to produce heat, see below how fossil fuels generate electricity:

Burn fuel → Heat water to make steam → Steam turns turbines → Turbines turn generators → Electrical power

Burning any fossil fuel produces carbon dioxide, which adds to the greenhouse effect.

Coal

We obtain 23% of our electricity from coal-fired power plants. Mining and burning coal produces waste and atmospheric pollution, which poses environmental problems. Sulphur dioxide fumes from coal power stations cause acid rain, which damages trees and lakes. An advantage is it does need processing before burning

Gas

Currently the main source of power for electricity production in the UK. It can be burnt directly and is easy to transport through pipelines. Gas needs to be processed before use to remove water and other impurities. Gas power stations can be brought into service quickly.

Oil

Oil is hardly used for electricity production (in the UK). Oil is used for some heating systems and is the main fuel used in road and sea transportation. It needs to be refined from crude oil before it can be used. Stocks of oil will run out before coal, although there is no immediate shortage.

Nuclear Power

22% of the UK's electricity comes from nuclear reactors, in which uranium atoms are split to generate heat. This process is known as fission. A vast amount of energy can be produced by this process from a relatively small amount of uranium. Nuclear waste is highly hazardous and can have long-lasting effects on the health of humans and animals for thousands of years if not dealt with carefully.

Key Questions

- **What is meant by the term finite resource?**
- **What is meant by the term renewable energy?**
- **Explain how each of the renewable energy types produce electricity.**
- **List the advantages and disadvantages that fossil fuels have on the environment.**
- **How is energy generated by Nuclear Power?**

Renewable Energy

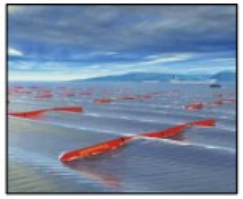
Recently due to the concerns over pollution and the possibility that some sources of fuel might eventually run out or become uneconomic to obtain, there has been much greater support for renewable sources of power. Renewable sources provide 25% of the electricity we use.

Wind power

Hydroelectric power

Tidal power

Solar power



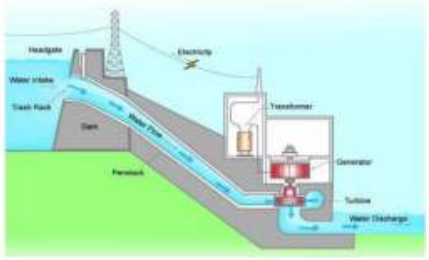
Wave power

Biomass

Year 11 Knowledge organiser— ENERY STORAGE

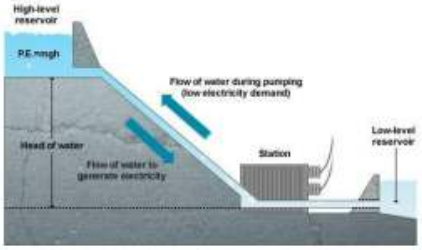
Kinetic pumped storage systems

A similar system to hydroelectric power generation is used in pumped storage systems. Here is an example of a hydroelectric dam system, where 2 reservoirs one at a low level, and one up a mountain.



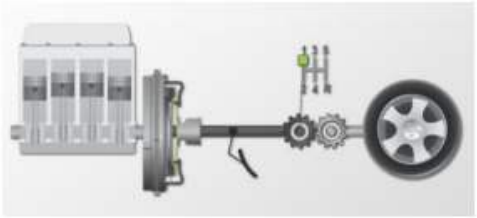
They are a good way of dealing with sudden high demand for electricity. For example in the middle of a TV ad, when people go an make a cup of tea.

The pumped storage system instantly releases electricity into the system by opening valves to allow water to flow from the high reservoir to the lower one through turbines. Cheap excess electricity is used to pump the water back up to the top reservoir, ready for sudden peaks in demand the next day.



Mechanical energy storage

A way in which we can store energy is using a flywheel. Flywheels are a heavy spinning mass that continues to spin when the driving force stops.



Clockwork is still used for storing energy in toys and mechanical devices. Normally a key is used to wind up a spiral spring before forcing it into a smaller space, where it is stored as potential energy with a system of gears being used to release the energy slowly.

Electrical energy storage

Capacitors

Capacitors are the most popular non-chemical method of storing electricity and their invention predates the battery. They consist of two plates of opposite polarity; when the capacitor is charged, the positive charges migrate to one plate, and the negative to the other.

Supercapacitors are used in electric vehicles because they can be recharged many more times than batteries.

Batteries

There are 2 types of battery: primary (single-use) which we use and discard; and secondary (rechargeable).

Both are extremely useful when we need electrical power in locations where mains electricity would be difficult.

Primary battery

Secondary battery

Rechargeable batteries typically have a cell voltage of 1.2 volts, so in a 12-volt device you would need 10 rechargeable batteries but only 8 single-use batteries.

Batteries come in a variety of shapes and sizes, with large lead-acid batteries for cars, trucks and even submarines at one end of the scale; and miniature batteries such as those used in hearing aids at the other.

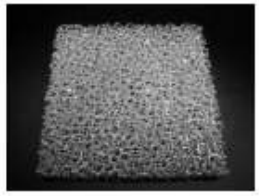
Key Questions

- **What is the time of day to store energy in a pumped storage system?**
- **How can a flywheel store energy?**
- **Give two disadvantages of secondary batteries.**
- **Create a flowchart, to explain how a kinetic pumped storage system works.**
- **List the different types of batteries available.**
- **When did batteries become the most popular energy storage method for toys. Explain the advantages of this development.**

Year 11 Knowledge organiser— MODERN MATERIALS

Modern Materials
Modern materials are new materials developed to have properties that are useful when designing and making products. They are produced through the invention of new or improved processes.

Graphene
Graphene is a very thin 2D material layer of carbon that was discovered and extracted from graphite in 2014. It is a very strong and very light material. It is harder than diamond, about 300 times stronger than steel and is currently the lightest known material. Graphene is transparent and conducts electricity and heat even better than copper. It is extremely flexible, which is unusual for such a tough, strong material.

Metal Foam


Metal foams, are made by injecting gas into the metal when it is a liquid state.This creates a foam that is very lightweight and has high compressive strength. It can be used as soundproofing or for crash protection in vehicles as it is light enough to be carried in cars, without reducing their speed.

Titanium
Titanium is a fairly new metal in comparison to others, and it is the fourth most abundant metal. It is particularly useful due to its high corrosion resistance, even to saltwater and chlorine. It also has a high strength-to-weight ratio, making it suitable for use in applications such as knee replacements. Titanium can be alloyed with other metals such as aluminium.

Coated Metals
Coated metals include anodised aluminium, nickel plated steels and polymer-coated aluminium.
Anodised aluminium - aluminium covered with a thick oxide layer.
Nickel-plated steel - process of electrolysis to add the metal nickel to a steel object.
Polymer-coated aluminium - aluminium is either dip coated or powder coated.

Liquid Crystal Display
A LCD is a laminated material of two layers of glass with a liquid crystal core. It lets light go through when a voltage is applied, or block light when the voltage is switched off. LCDs are often used in items such as digital watches and flat screen televisions. Many LCDs work well by themselves when there is other light around, whereas others need a backlight.

Corn Starch Polymers
They were developed to replace oil-based thermoplastics. They are often used in the manufacture of products which are intended to have a short lifespan, such as disposable cutlery.

Corn starch polymers are made from polylactic acid found in high starch vegetables such as potatoes, corn and maize. These are renewable sources, which is beneficial, and they don't task as much energy to produce as the extraction of oil does. They decompose within a shorter time than oil-based polymers so they don't litter our environment.
They are also food safe.

BIOCOMPOSTABLES: MADE FROM CORN

Key Questions
- **What is graphene being used for?**
- **List applications of titanium.**
- **Gather a range of images of metals that are coated.**
- **Explain the term teflon.**
- **What are the advantages of corn starch polymers?**

Nanomaterials
They have tiny parts less than 100 nanometres in size. A nanometre is one billionth of a metre. Nanomaterials are used as surface coatings or thin films, such as computer chips.

They are also used in sports equipment, such as tennis rackets and golf shoes, where nanoparticles are added to the materials to make them stronger, while not increasing the weight.

Also, nanoparticles are used in clothing such as socks due to their antibacterial properties, to reduce the absorption of sweat.

Teflon
Teflon is the trade name for PTFE. It is best known for being used on the surface of pans to ensure that food being cooked does not stick. Another application of teflon is that its used in clothing to make it difficult for dirt to stick to the fabric. PTFE is unreactive, so it is also used to make pipes and containers for chemicals.

Year 11 Knowledge organiser— SMART MATERIALS

Smart materials

They are materials that have one or more properties that can be significantly changed in a controlled fashion by an external stimuli. These influences could be, for example, stress, temperature, moisture or pH. These changes are often reversible when the environment changes.

Thermochromic pigments

Thermochromic materials change colour at specific temperatures. They are available as plastic, ink and dyes for textiles and paint.
They have many use, for example:

- Plastic strips used as thermometers that are applied to children's foreheads.
- Colour indicators on drinks cans to show whether the contents cold enough to drink.
- Baby spoons that change colour when the food is too hot; these are a safety feature to ensure the child's food is a safe temperature.

Shape memory alloys

If materials made from shape memory alloys (SMAs) are bent and deformed, they will return to their original shape when heated. This is a useful property when:

- A response to a change in temperature is needed (for example, in fire alarm systems or controllers for hot water valves in showers).
- A damaged product needs to be repaired (for example, if someone bends a glasses frame, it can be returned to its original shape by being heated).

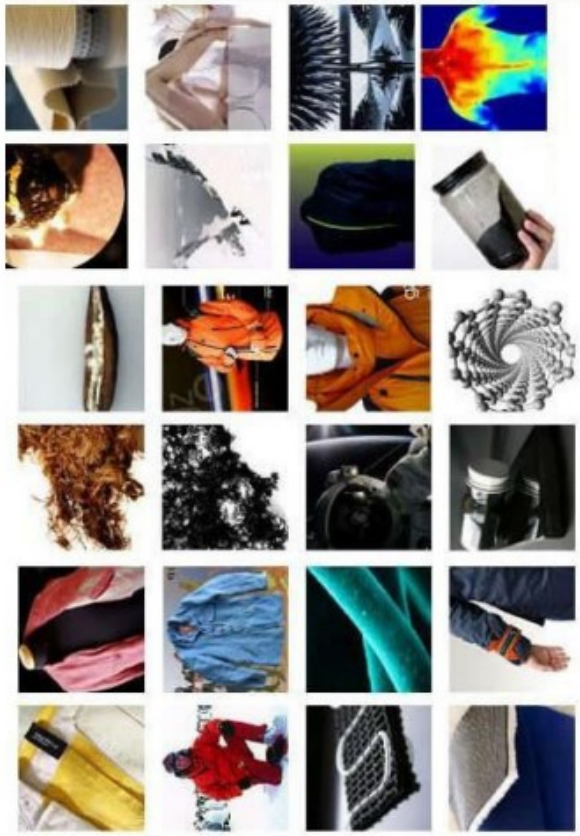
Photochromic pigments

Photochromic materials change colour if the level of light changes. Examples include:

- Lenses in sunglasses that become lighter or darker depending on the light conditions.
- Security markers that can only be seen in ultraviolet light.
- Bracelets that change colour to tell you if you are getting too much sun; these can be an indicator to tell you to reapply sun cream.

Key Questions

- **What is the definition of a smart material.**
- **Give a 5 examples of where thermochromic pigments are used.**
- **Give 5 examples of where shape memory alloys are used.**
- **Give 5 examples of where photochromic pigments are used.**



Year 11 Knowledge organiser— COMPOSITE AND TECHNICAL TEXTILES

Composites

They are materials made from two or more different materials, and combine the properties of the materials they are made from.

Concrete is an example of what is known as a particle composite. It is a mixture of cement, sand and stones; water is added during the manufacturing process.
Combining these materials creates a composite with very good compressive strength, however, if concrete is to be used somewhere where it needs tensile strength, steel reinforcing is added.

Glass-fibre reinforced plastic (GRP), combines strands of glass fibres which are strong but brittle, with a flexible polymers. This makes a composite material that is tough but not brittle.

Carbon-fibre reinforced plastic (CRP) has a very high strength-to-weight ratio so is popular in products which take very harsh loading and need to be lightweight, such as those used in the aerospace industry and motor racing.
It gives a high quality finish and a better strength-to-weight ratio, but is more expensive than GRP.

Technical Textiles

Technical textiles are textile materials and products that are manufactured for their technical and performance properties rather than their aesthetic characteristics.

Conductive fabrics have either conductive fibres woven into them or conductive powders impregnated into them. They have been built into competitors' jackets for fencing contests. As the sword strikes a panel, it records this, as the metal of the sword has touched the pad with the conductive fabric in it.

Microfibre is a very thin synthetic material and is often used for outdoor clothing and sportswear. It is because it's breathable, durable, crease resistant and easy to care for.

Fire-resistant fabrics are used on items such as firefighters suits and children's clothing. Nomex is a brand name for fire-resistant fabric made from a polymer called meta-aramid. Nomex thickens when heated, therefore increasing protection.

Kevlar is formed by combining terephthaloyl chloride and para-phenylenediamine. These threads woven together create an incredibly strong material. Examples are bulletproof vests.

Gore-Tex has been designed to be a waterproof yet breathable textile. It is used in clothing to provide a waterproof product that also releases perspiration vapour, and therefore is comfortable to wear than traditional waterproof materials.

Key Questions

- **Find images of products that are made from each of the composites (concrete, GRP and CRP).**
- **Find images that are made using Gore-Tex.**
- **Explain the terms composite material and technical textiles.**

Year 11 Knowledge organiser— SYSTEMS APPROACH TO DESIGNING

A systems approach explained

To work out how any product containing electronics works, you have to ask the following questions:

1. What does the product do? (What is the output?)
2. How does it do it? (What is the process?)
3. What happens to allow this to work? (What is the input?)

These 3 elements of output, process and input are what we call a systems approach to designing. The use of system diagrams (above) show this information.

Take a streetlight for example, the input would be a light sensor detecting it is dark, the process is the switching on of the light, and the output is the light being given off to light up the area below.

Key Questions

- **What is a system diagram?**
- **Find 10 electronic products and create a system diagram for each, showing the input, process and output.**
- **Draw the electronic symbols for each of the components on this page.**

Input devices

Light dependent resistor (LDR) - is a component which the resistance to the flow of electrical current through it changes as the light intensity that falls up on it alters. Examples include streetlamps, nightlights.

Thermistors - is a components in which the resistance the the flow of electrical current through it changes with temperature. There are 2 types; PTC and NTC, PTC works when the resistance increases when temperature increases. NTC works when resistance falls when temperature increases. Example uses include toaster, fridges and hair dryers.

Switches - there are a variety of switches that can be used to input signals to processing devices. They can be used to sense when objects apply pressure to them.

Processes

Electronic processes can be carried out by many components, but in recent years they are more frequently performed by microcontrollers.

Microcontrollers can be found in many products such as car engine control systems, remote controls, office machines, medical devices and toys.

Outputs

The output of an electronic system is generally the part that people are aware of. Whether it is light, sound or movement.

Lamps and LEDs - Lamps operate by passing an electric current through a very thin filament, which is usually made of tungsten. Due to poor energy efficiency they are rapidly being replaced by light Emitting Diodes (LEDs).

Buzzers & Speakers - These give out sound outputs. Buzzers fall largely into 2 types: electromechanical and piezoelectric. They are typically uses in alarm devices, timers and to confirm user input. Loudspeakers are devices that convert electrical signals into corresponding sound.

Year 11 Knowledge organiser— MECHANICAL DEVICES

Different types of movement
There are 4 basic types of motion in mechanical systems:

Linear motion - is movement in a straight line, such as on a paper trimmer.

Reciprocating motion - is movement backwards and forwards in a straight line, such as the movement of the needle in a sewing machine.

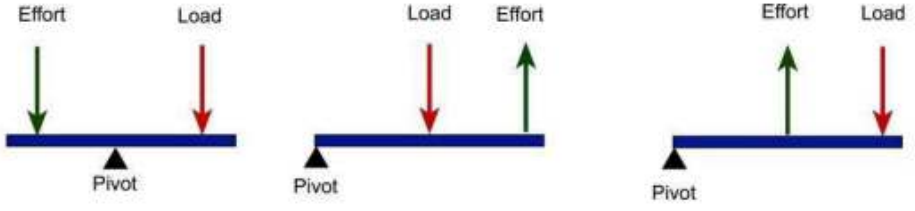
Rotary motion - is movement round in a circle, such as a wheel turning.

Oscillating motion - is movement swinging from side to side, such as a pendulum in a clock.

Key Questions

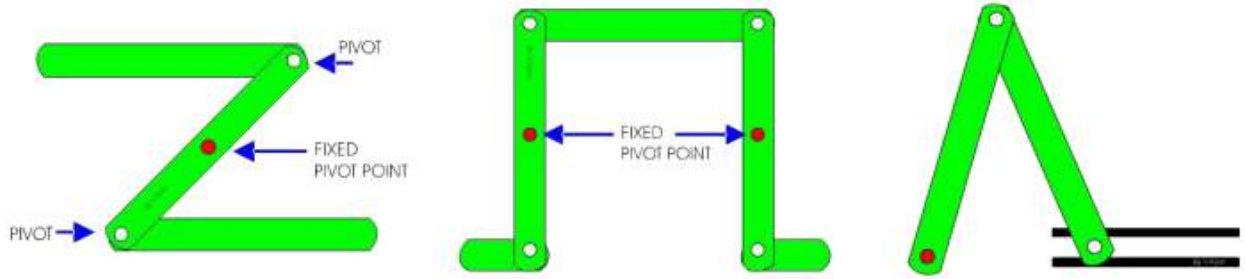
- **Draw a simple diagram to show each of the 4 types of motion.**
- **Find 3 examples (images)of products that use each class of lever.**
- **Using lollipop sticks, make each of the linkages and describe the change of motion.**
- **Find out the names of the different linkages on the page.**
- **Find 3 examples (images) of products that use each of the linkages shown to the left.**
- **What is meant by the term magnitude.**

Levers
Levers are possibly the oldest type of mechanism. A lever changes an input movement and force (effort) into an output movement and force (load). A lever moves around a fixed point called a pivot.



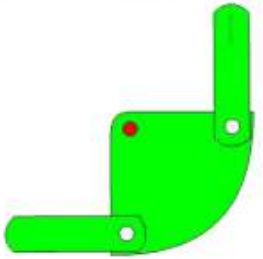
There are 3 basic types or orders of level. The order of lever depends upon the position of the load (L), effort (E) and fulcrum (pivot).
The load is the object to be moved.
The effort is the force applied to move the load. The fulcrum is the point where the load is pivoted.

Linkages
Linkages ar widely used in mechanisms to transfer force and can change the direction of movement. They are simply an assembly of levers to transmit motion and force.



Different linkages can be designed to transmit motions and force. The number and shapes of the linkages can change the direction of the force, and the position of the pivots can change the size or magnitude of the force. The closer the pivot is to the output end of the lever the larger the force is at the output.

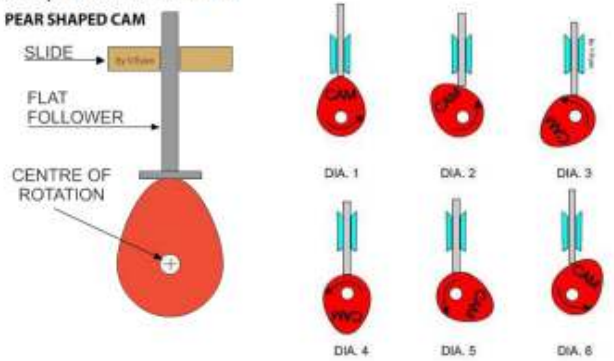
Images from www.technologystudent.com



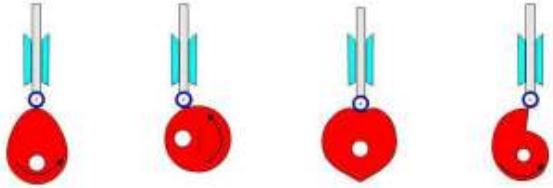
Year 11 Knowledge organiser— MECHANICAL DEVICES 2

Cams & Followers

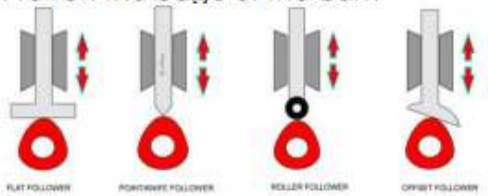
A cam mechanism has three parts: a cam, a slide and a follower. When the cam rotates, the follower moves up and down in a reciprocating motion. The pattern the follower moves up and down in is governed by the shape of the cam.



Cams can be shaped in any number of ways and this is determined by the way the follower is to move. The shape of the profile is known as the profile.



There are different types of follower but they all slide or roll on the edge of the cam

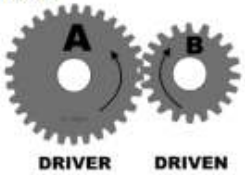


Images from www.technologystudent.com

Simple Gear Trains

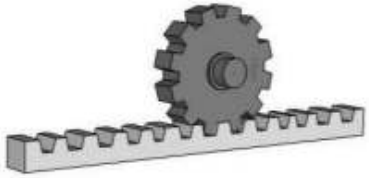
A gear train is a mechanism for transmitting rotary motion and torque. The gears have teeth, and interlock or mesh with one another to transmit the rotary motion.

Different size gears connected together either increase or decrease the speed of rotation and increase or decrease the torque transmitted.

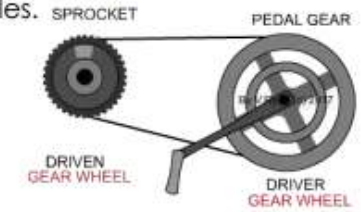


Simple gear train

A rack and pinion mechanism can turn rotary motion to linear motion or vice versa.

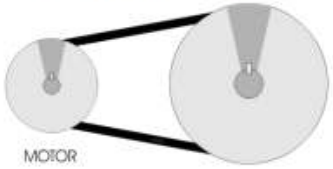


A chain and sprocket mechanism transfers rotary motion to rotary motion elsewhere in a machine, such as in bicycles and motorcycles.



Pulleys & Belts

Pulley systems transmit rotary motion to rotary motion in machines. A pulley is just a simple wheel with a groove in its rim. Two pulleys connected together by a flexible belt will transmit rotary motion and torque.



Working out velocity ratio

Here are the formula to work out the velocity ratio in a number of gear systems.

Simple gear train:

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

Chain and sprocket mechanism

$$\text{Velocity ratio} = \frac{\text{Number of teeth on the driven sprocket}}{\text{Number of teeth on the driver sprocket}}$$

Pulley system

$$\text{Velocity ratio} = \frac{\text{Diameter of the driven pulley}}{\text{Diameter of the the driver pulley}}$$

Key Questions

- **Describe the motion created by the different shapes of cam.**
- **What is meant by torque?**
- **How do you work out the velocity ratio of a gear train?**