Energy

Introduction

Energy is important as it forms the basic ideas of physics. This topic begins by looking at the generation of electricity. The form of energy which impacts upon our lifestyle daily. Electrical energy is transferred and consumed within our homes, schools, places of work etc. and there continues to be a great demand for this energy.

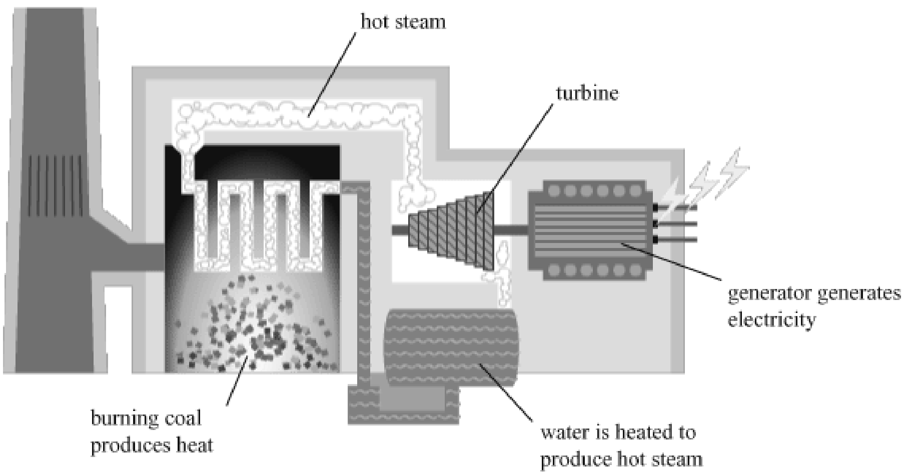
Most of our energy continues to be supplied by non-renewable sources such as nuclear and fossil fuels (coal, oil and gas). These sources are not present in unlimited quantities and will eventually run out. Alternative methods of meeting our demand for energy continue to be explored by scientists and engineers The renewable sources of energy (wind, solar, tidal etc.), which will never run out and will always be available, now meet some of our demand for energy and will, perhaps, have a greater role to play in the future on account of the work which is being carried out.

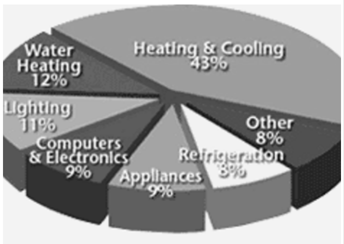
Energy from renewable or non-renewable sources of energy has to be converted into electricity in a power station. There are different types of station for different energy sources.

Generation of Electricity

Thermal Stations

A thermal power station generates electricity from fossil fuels. Oil or coal is burned causing chemical energy to change to heat, which results in water turning into steam in the boiler. The steam then travels at high pressure and turns a turbine as it passes. The turbine then turns the generator which converts kinetic energy into electrical energy.





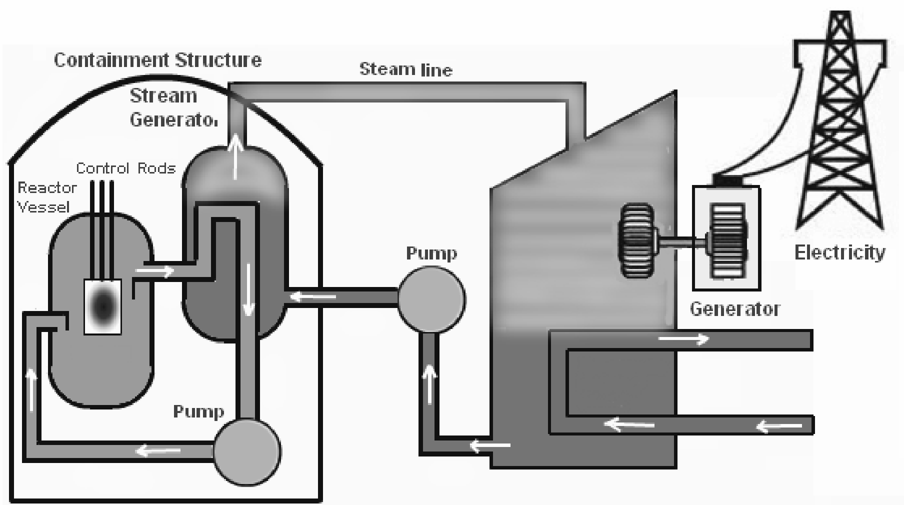
A pie chart showing energy use in the home

How can we use less energy in the home?

A dynamo is a small generator.

Nuclear Power Stations

Nuclear power stations, as you should know from Waves & Radiation, make use of energy stored inside unstable atoms. The sequence of energy changes which occur inside a nuclear power station are similar to the changes in a thermal power station. Instead of chemical energy being burned to produce heat, nuclear energy itself is used to heat water in the nuclear reactor.



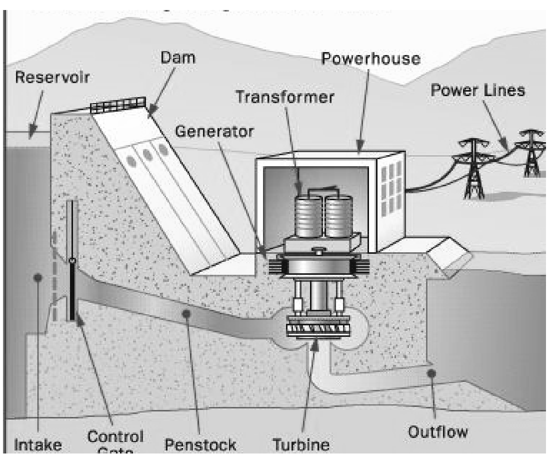
Nuclear fuel - Uranium

Unlike power stations which burn fossil fuels nuclear power stations do not release harmful green house gases into the environment. Nuclear fuel will also not run out as quickly as the fossil fuels and produces huge amounts of energy. Many people, however, are opposed to nuclear plants as they are fearful of the catastrophic problems which may arise if something goes wrong and are concerned about radioactive waste.

Where do you store radioactive waste?

Hydroelectric Power Stations

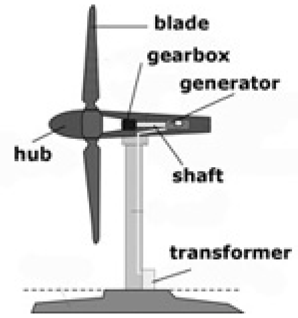
Hydroelectric power stations convert the kinetic energy of moving water into electrical energy. The water which is stored high up behind a dam has gravitational potential energy. This is transferred to kinetic energy as the water is released and rushes down through tubes inside the dam. The moving water drives turbines which in turn rotate generators, which may be built inside the dam.




Cruachan Hydro Power Plant. Why is Scotland suited to hydroelectric power stations?

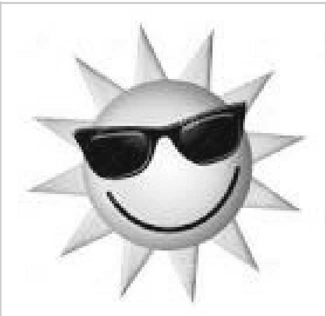
Whitelee Wind Farm

Wind Turbines



Wind turbines have huge blades mounted on a tall tower. The blades are connected to a generator. As the wind blows, it transfers some of its kinetic energy to the blades, which turn and drive the generator. Wind turbines may be grouped together in windy locations to form wind farms.

Solar Power



Our main source of energy– the Sun.

The sun is our main source of energy. There are two types of solar panels which use this source of energy:

Photovoltaic (PV) and Thermal

Photovoltaic cells generate electricity. These devices convert light energy directly into electrical energy. Small solar cells are used in calculators. A group of solar cells may be described as an array. An array of solar cells may be used to power road signs in remote areas, and larger arrays are used to power satellites in orbit around the Earth.

Thermal solar panels use the energy from the sun to heat up water or liquid inside the panel. These thermal solar panels can be used to heat up water in a house for bathing or heating. Thus, saving on electrical energy.

Tidal Power

SeaGen Turbine

The movement of the tides flowing in and out can be harnessed using the combination of turbine and generator, similar to wind power. The turbine is rotated by the flowing water and this rotates the generator resulting in electrical energy.

Biomass

Some power stations burn wood from forests of fast-growing trees. These power stations work in the same way as traditional thermal stations. Burning wood also puts carbon dioxide into the atmosphere but the next generation of trees absorb it again in photosynthesis. So, biomass is carbon neutral. Other organic material can also be burnt to generate electricity.

Sugar from sugar cane can be changed into alcohol to power cars.

Advantages and Disadvantages of Sources

Energy Source	Advantages	Disadvantages
Fossil Fuels	Reliable	Create pollution and will run out
Nuclear Power	Reliable	Will run out and produce dangerous waste that is hard to dispose of
Hydroelectricity	Clean and cheap to run	Expensive to set up and output could be affected by drought
Wind	Clean and cheap to run	Expensive to set up and wind does not always blow
Solar	Clean and cheap to run	Not always sunny and output does not always outweigh initial cost to set up
Tidal	Clean, cheap to run and produces a lot of electricity once running	Very expensive to set up and could be hazardous to local wildlife
Biomass	Does not release carbon dioxide and reduces landfill	Expensive and requires a lot of land

Efficiency of Energy Generation

All methods of energy generation have both advantages and disadvantages. Efficiency of electricity generation is also important because the better the method of generating electricity, the less energy is wasted.

Scientists and engineers continue to work in order to find the most efficient, cost effective and most environmentally friendly way to produce electricity. Once the electricity is generated, it needs to be transported from the power station or generator to the consumer. This is done using a system of pylons and cables called the National Grid.

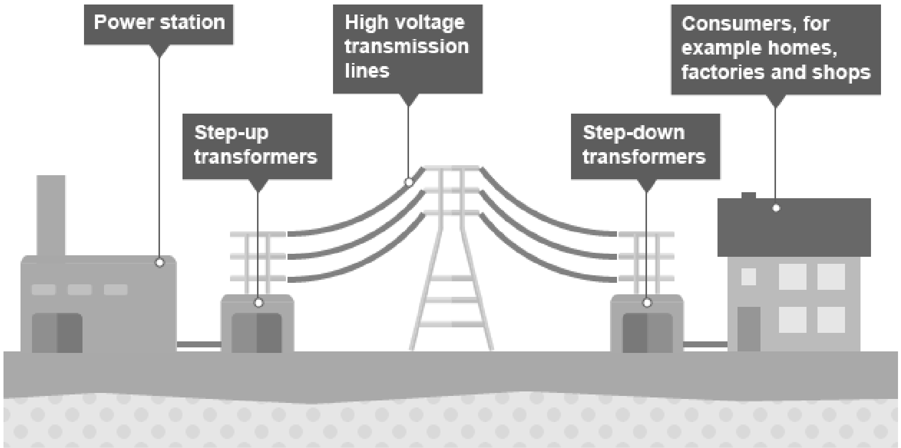
Some energy is 'lost' in the transmission lines as heat, due to resistance in the cables and a small amount of sound energy. If you have ever stood near a pylon you may have heard a faint buzzing noise, as some energy is transferred to sound.

A common sight?
Even in Scotland.

Pelamis wave energy converter.

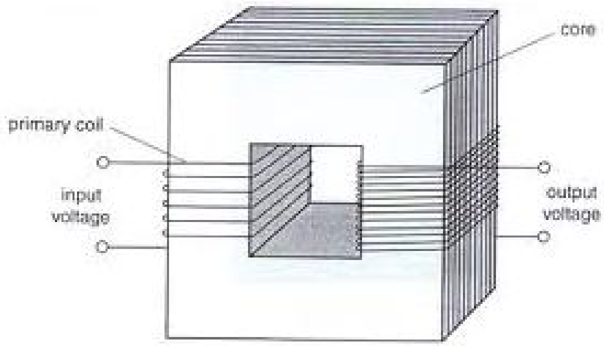
The energy saving logo seen on efficient appliances.

A transformer used in electrical distribution. Is there one near the school?



We can reduce the loss of energy as heat by ensuring that the electricity in the transmission lines has a low current. Transformers, as seen in the diagram above, are used to lower the current. When there is a low enough current, less electrical energy is lost as heat.

A transformer is made up of an iron core and two coils of wire (the primary coil and the secondary coil) as shown below.



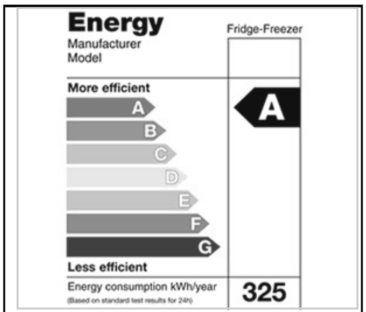
Another transformer.

Energy in the Home

The way we use electricity in the home affects the amount of electricity we need to generate. If we waste energy then we need to make more.

There are steps we can take in order to reduce our carbon footprint and the amount of energy we use, such as:

- have roof and cavity wall insulation installed to reduce the heat energy lost from our homes
- have our windows double or triple glazed to reduce heat loss through our windows
- switch off unwanted lights and appliances to reduce unnecessary energy use
- make use of energy efficient electrical appliances such as low energy light bulbs where possible



Most appliances have energy labels which inform you about efficiency.

Energy and Power

To compare different components it is often useful to compare the **rate** at which energy is transformed, that is the energy transformed **each second.** This electrical energy transformation each second is known as the **power.** The power of an appliance can be found using the following equation:

$$P = \frac{E}{t}$$

Power (P) is measured in watts, W, energy (E) is measured in joules, J, and time (t) is measured in seconds, s.

1 watt is equivalent to the transfer of 1 joule per second.

Example 1

An electric kettle uses 540 kJ of electrical energy in 5 minutes. Calculate the power rating of the kettle.

$P = \frac{E}{t}$ $\quad$ *E = 540 kJ = 540 000 J*, *t = 5 mins. = 300 s*

$= \frac{540\,000}{300}$

$= 1\,800\ W$

Example 2

An electric motor on a ceiling fan with a power rating of 115 W uses 207 kJ of electrical energy. For how long was the electric motor working ?

$t = \frac{E}{P}$ $\quad$ *E = 207 kJ = 207 000 J*, *t = 115 W*

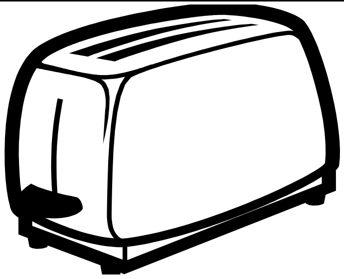
$= \frac{207\,000}{115}$

$= 1\,800\ s$

The power rating of a smart television is approximately 300 W.

The power rating of hairdryers ranges from 800 to 1800 W.

Every appliance has a power rating plate.



Appliances which change electrical energy to heat energy have a higher power rating.

Electrical Power

Electrical energy is not free ! Every household pays for the amount of electrical energy used. The amount of energy used is measured by the electricity meter next to the consumer unit. The amount of energy used is determined by the power rating of the appliances and the length of time the appliances are used for.

Every appliance has a power rating marked on it, in either watts (W) or kilowatts (kW). The greater the power rating of the appliance. the more energy it uses per second. The table below gives approximate power ratings for a number of household appliances.

Appliance	Power Rating (W)
Computer	250
Dishwasher	1200
Vacuum Cleaner	600
Washing Machine	500
Blender	300
Toaster	1200

Appliances which change electrical energy to heat energy use more energy.

Also the longer the time an appliance is used, the more energy it uses. So, to save energy and money, always switch off appliances after use.

Efficiency

Appliances and devices (machines) can be used to transform one kind of energy into another. For example, an electric motor transforms electrical energy into kinetic energy. This energy might be further transformed into potential energy if the motor is used to drive a lift. However, not **all** the electrical energy which is supplied to the motor will be transformed into the final **useful** form of energy. Some may be transformed into heat, due to friction, and sound.

Energy efficiency can save you money and conserve resources.

Although no energy has been destroyed, some is ‘wasted’ as it cannot be used. This makes the machine inefficient. Efficiency is measured by expressing the **useful** energy output as a percentage of the **total** energy input.

$$\text{\% Efficiency} = \frac{\text{useful energy output}}{\text{total energy input}} \times 100$$

The formula, above, can also be applied to power rather than energy.

Efficiency Examples

Worked Example 1

What is the efficiency of a light bulb which uses 550 J of electrical energy and gives out 110 J of light?

$$\% \text{ Efficiency} = \frac{\text{useful energy output}}{\text{energy input}} \times 100$$

$$= \frac{110}{550} \times 100$$

$$= 20\ \%$$

Worked Example 2

A power station produces 150 000 kW of heat, which gives out 60 000 kW of electrical power. Calculate its efficiency.

$$\% \text{ Efficiency} = \frac{\text{useful power output}}{\text{total power input}} \times 100$$

$$= \frac{60\ 000}{150\ 000} \times 100$$

$$= 40\ \%$$

Energy saving light bulbs are efficient?

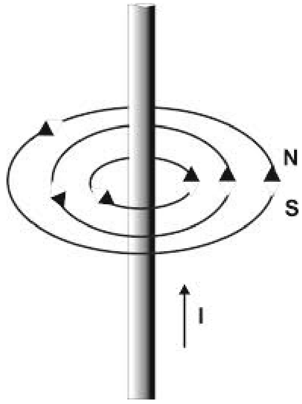
This is the logo of an appliance company which prides itself on efficiency.

What energy efficient car is developed by this company?

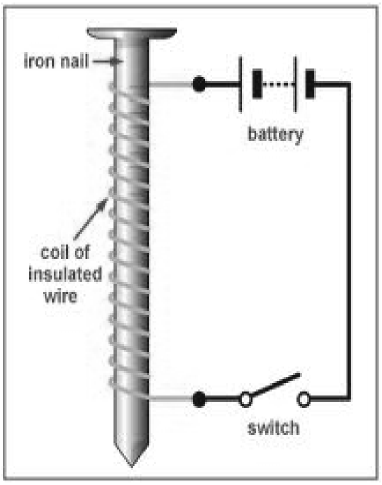
James Clerk Maxwell - the Scottish physicist - famously developed the theory on electromagnetic radiation.

Electromagnetism

When a current passes through a wire,
a magnetic field is produced.



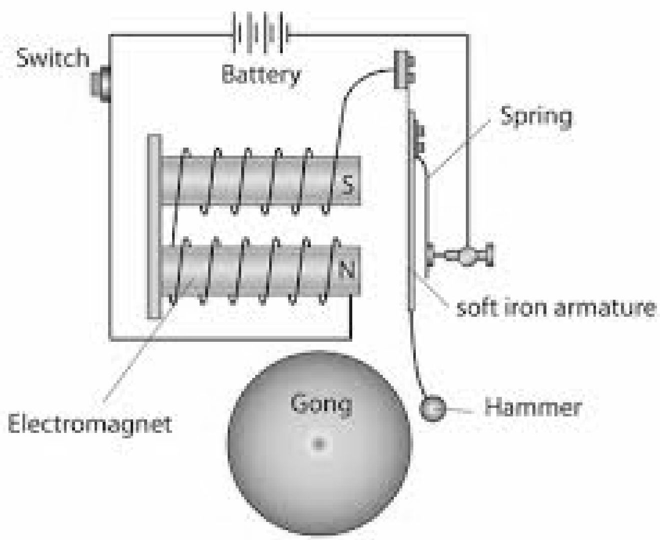
By wrapping a wire round a soft iron core an electromagnet is produced. The more wires that are wound together the greater the strength of the electromagnet. When the current is switched off, the magnetic field fails.



A simple electromagnet, like the one to the left, is easy to make and can be used to demonstrate the on–off mechanism which is put to use in many ways. Typical uses of this effect are the bell and the relay.

An electromagnet lifting scrap.

In the bell the clapper is pulled towards the gong by the electromagnet but this causes a break in the circuit and the electromagnet fails. The spring attached to the clapper makes the clapper return to its original position and the whole action starts again.



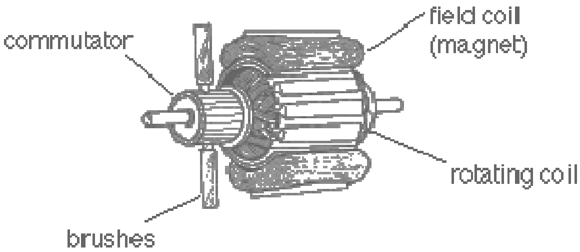
The Transrapid maglev train uses electromagnetic suspension to lift itself above the track.

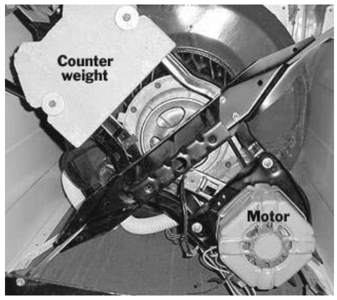
A relay is an electromagnetic switch which can be used to operate a high current circuit.

The Electric Motor

When a wire carrying a current is placed between the poles of a magnet then the wire has a force acting on it. The direction of the force can be changed by reversing either the current or the direction of the magnetic field.

In an electric motor, coils of wire are placed between the poles of a magnet and, as a current flows in the wires, the coils will rotate. The coils will keep on rotating because of the **commutator**. This is a ring split into two which reverses the direction of current. Current is fed in to the coils by the **brushes**.

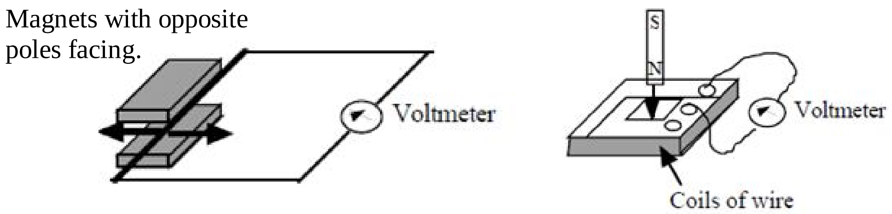


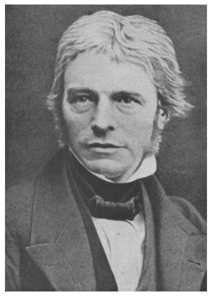


Inside of a washing machine.

Induced Voltage

If a conductor cuts across the lines of a magnetic field, then a voltage will be induced across the ends of a conductor. Note the magnet can move with the conductor stationary or vice versa. An induced voltage will be produced provided the conductor experiences a **changing magnetic field.**



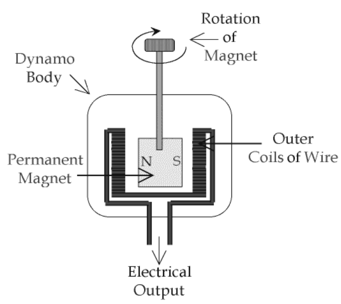


Michael Faraday who built the first electric motor around 1830.

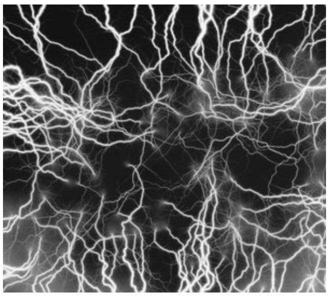
The size of the induced voltage depends on -
• the magnetic field strength
• the number of coils
• the speed of the motion

This is the foundations of electricity generation.

Generators in power stations rely upon the relationship between electricity and magnetism. Generators do the opposite of electric motors as they change kinetic energy into electrical energy.



A simple diagram of a dynamo.

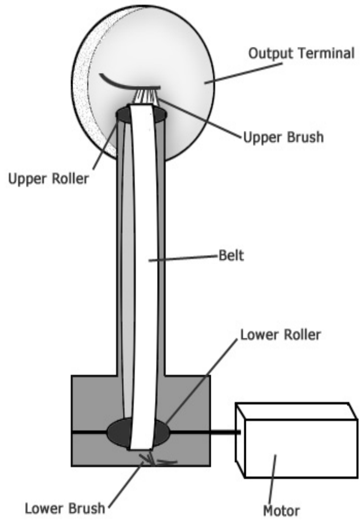


Static Charge

Electrical & Electronic Circuits

Charge

With your teacher you used a Van de Graaf generator, a machine which rubs a rubber belt over a plastic roller. When the belt is **rubbed** it gets an electric charge, which it passes to the dome. This static charge can create sparks.



You found out that there are two types of electrical charge, **positive and negative.**

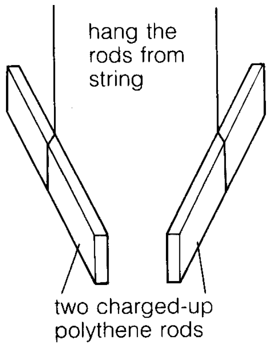
Electricity is a **flow of tiny, negatively charged particles called electrons.** Electrons are much smaller than atoms.

Van de Graaf fun.

You also carried out experiments in which pieces of plastic were rubbed to give an electrical charge.

Any material can be given an electric charge by rubbing.

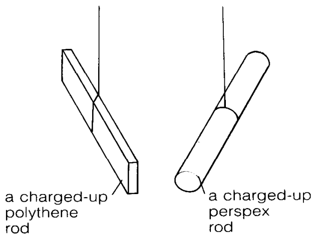
When plastic rods which both had positive charges were brought close to each other the rods moved away - they repelled.



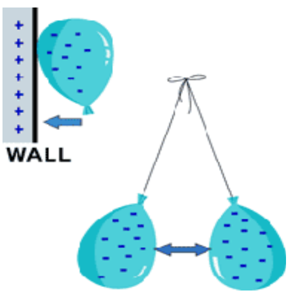
Positive is repelled by positive.
Negative is repelled by negative.

We say that **like charges repel**.

When a positively charged rod is brought close to a negatively charged rod they attract. Positive charges are the opposite of negative charges.



We say that **opposite charges attract.**



Balloons and static electricity.

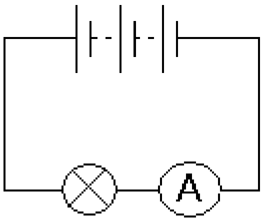
Balloons can be given an electric charge by rubbing.
The picture opposite shows that **like charges repel** and **opposite charges attract**.

Current

Current is the flow of charges (electrons) around a circuit.

Current is measured in amps - short for Amperes. The symbol for amps is A.

Current is measured with an ammeter, **to measure current the ammeter is placed in the circuit along side the component.**



The ammeter in the circuit, above, is measuring the current flowing through the bulb.

The Amp is named after the famous Scientist - Andre Ampere.

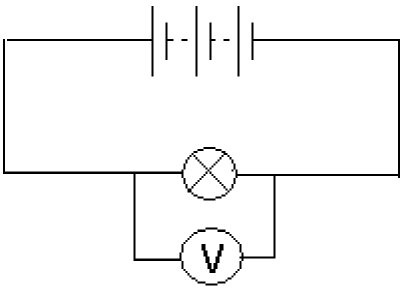
Voltage

Batteries provide electrons with the energy to move. The push a battery gives to electrons is called the voltage of the battery.
Voltage is a measure of the energy given to the charge (electrons) in a circuit.
When batteries are joined together the voltages can add or cancel depending on the way the batteries are joined.

Batteries change chemical energy into electrical energy.

Voltage is measured in Volts. The symbol for volts is V.

Voltage is measured with a voltmeter, **to measure the voltage across a component the voltmeter is placed across the component.**



The voltmeter in the circuit, above, is measuring the voltage across the bulb.

The Volt is named after another famous Scientist, Allesandro Volta.

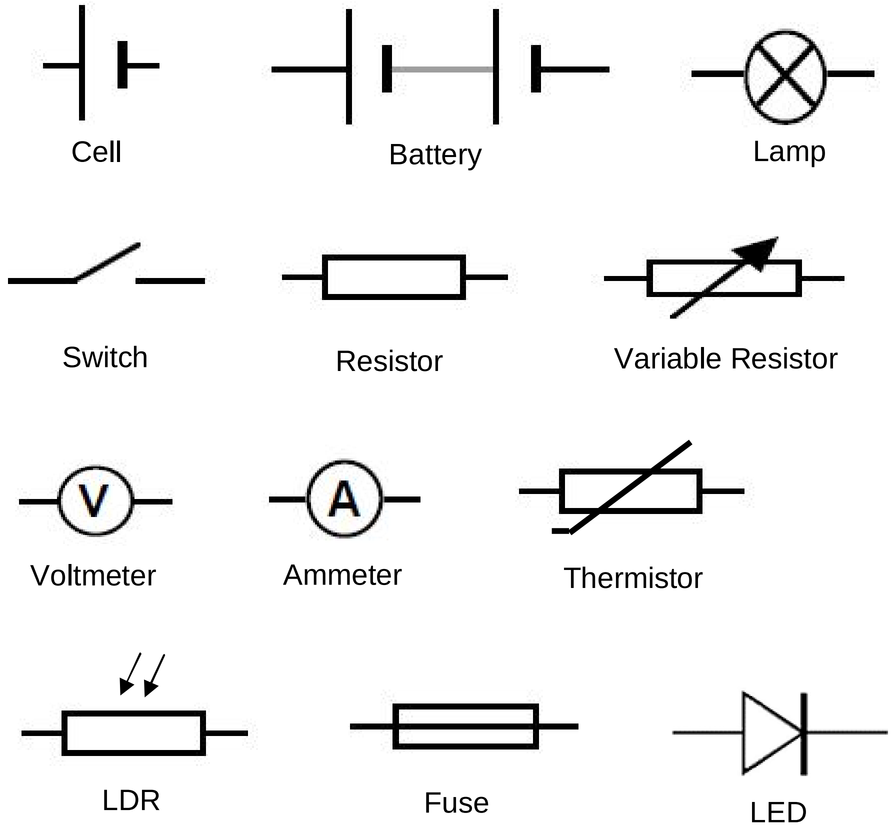
Switches control the flow of electricity.

Electricity enters our homes through a fuse box as shown above.

LED lamps are becoming more common. Why?

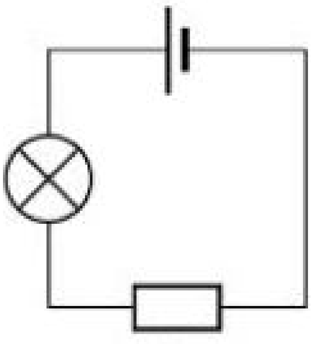
Circuit Symbols

Each electrical component is represented by a symbol, which is easy to draw. As you know the symbols are used when drawing electrical circuits. All the scientists in the world - no matter their language - have agreed to use the same symbols. Most of the symbols below you should already know.



Series Circuits

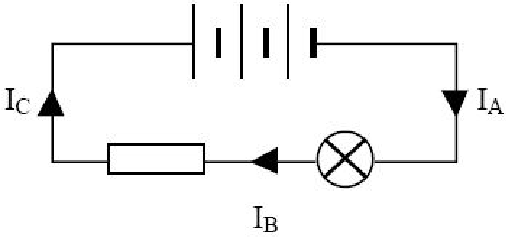
A series circuit is a circuit in which the components are connected one after the other, in series. There is only one path for the current to follow. Any break in the circuit will stop the flow of charge and cause the whole circuit to stop working.



A series circuit with a cell, a lamp and a resistor.

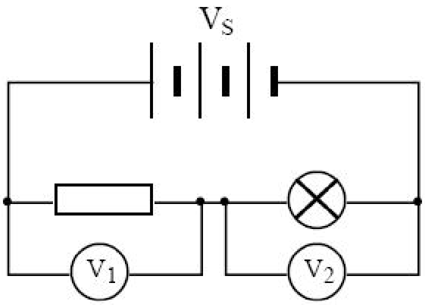
Current and Voltage in Series Circuits

The current is the same at all points in a series circuit because there is **only one** path for the current to flow.



$I_A = I_B = I_C$

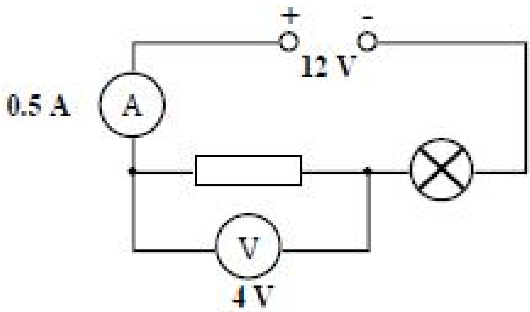
The sum of the voltages across the components in a series circuit is equal to the voltage of the supply.



$V_s = V_1 + V_2$

Example

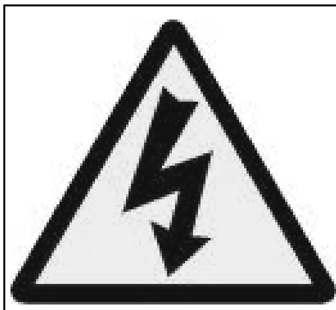
In the circuit below the ammeter reading is 0.5 A and the voltmeter reading is 4 V.



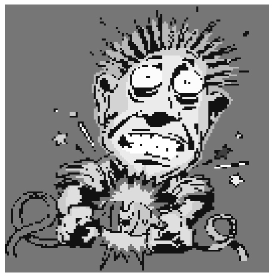
(a) What is the current through the lamp?
(b) What is the potential difference across the lamp?

(a) The current through the lamp is 0.5 A as the current is the same at all points in a series circuit.

(b) Voltage across lamp = Supply voltage - voltage across resistor
= 12 - 4
= 8 V



Watch out for the electrical hazard symbol.

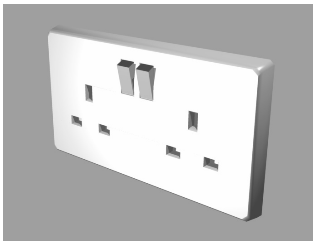


Electricity from the mains can flow through our bodies.

Electricity meters measure the amount of electricity used.

Christmas tree lights…
series or parallel ?

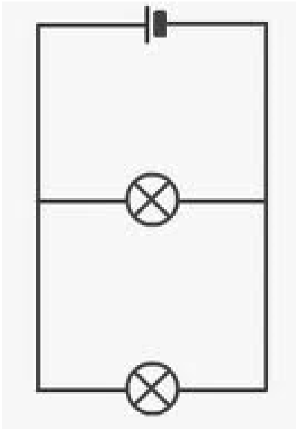
Cars have many parallel circuits to ensure that all the electrical parts work.



Sockets in a house-hold are arranged in special parallel circuits called ring circuits.

Parallel Circuits

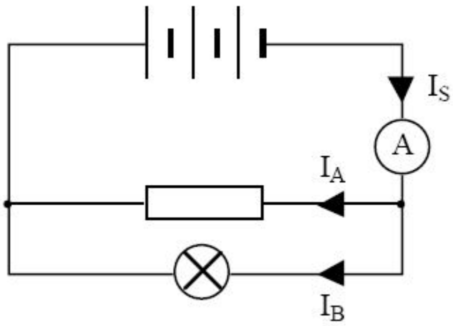
A parallel circuit is a circuit which has more than one path (branch) for the current to follow. A break in one of these paths will not prevent other paths from carrying charge. They are called ‘parallel’ circuits because on a circuit diagram, the different branches of the circuit run parallel to each other.



A parallel circuit with a cell and two bulbs. Each component is on a different branch.

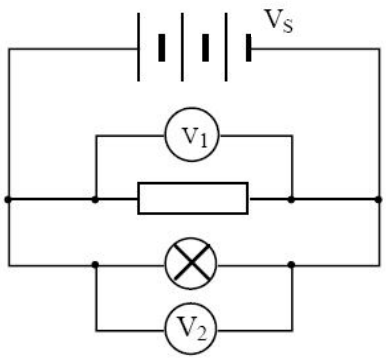
Current and Voltage in Parallel Circuits

In a parallel circuit the current has **more than one** path to follow. This means that the supply current splits through each parallel branch.



$I_s = I_A + I_B$

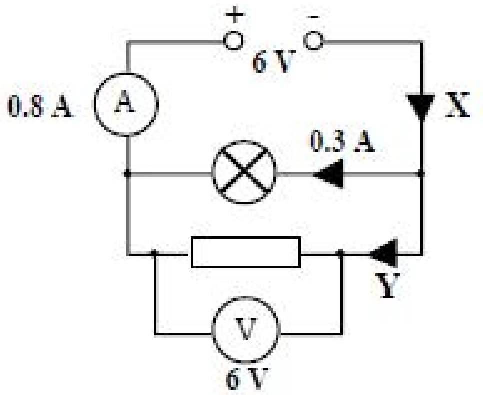
The potential difference across components is the same for all components.



$V_s = V_1 = V_2$

Example

In the parallel circuit below the ammeter reads 0.8 A, the current through the lamp is 0.3 A and the voltmeter reads 6 V.



(a) What is the voltage across the lamp?
(b) What are the current values at X and Y?

(a) The voltage across the lamp is 6 V as the voltage across each branch in a parallel circuit is the same.

(b) The current at X is 0.8 A as it is the supply current (it has not split between the branches yet).

The current at Y is 0.8 - 0.3 = 0.5 A
(as the supply current of 0.8 A is split between the branches).

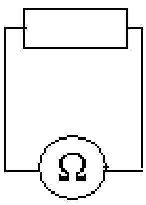
Resistance

Materials oppose current and some materials oppose it more than others. This opposition to current is called resistance. Every material has an electrical resistance. **The greater the resistance, the smaller the current that flows.**

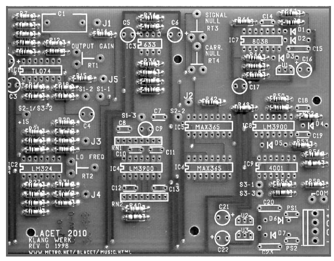
Every electrical component has resistance. Components called resistors are used to provide resistance in circuits. **Resistors cause electrical energy to be changed to heat energy.**

Resistance is measured in ohms. The Greek letter omega (Ω) is the symbol for ohms.

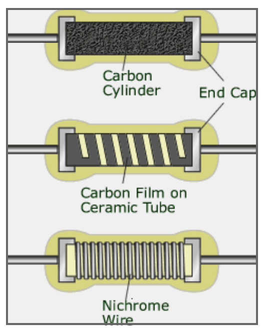
Resistance can be measured with an ohmmeter. To measure resistance, connect the ohmmeter directly across the resistor or component.



Multi-meters can be used as voltmeters, ammeters and ohmmeters.



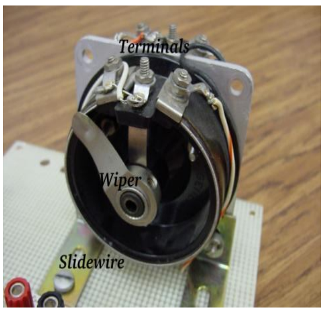
Resistors on a printed circuit board.



Inside a resistor.

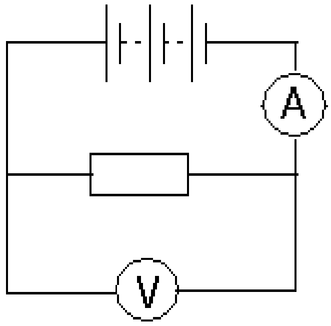
Resistance in electrical cables can prove costly.

Georg Ohm,
the German physicist.



Inside a variable resistor.

Alternatively resistance can be calculated from ammeter and voltmeter values.



The current through the resistor (or component) is measured with an ammeter and the voltage across it is measured with a voltmeter. The resistance is then calculated using :

$$\text{resistance} = \frac{\text{voltage}}{\text{current}}$$

Resistance has the symbol R, voltage V and current I. So

$$R = \frac{V}{I}$$

This relationship is known as **Ohm's Law**.
For resistors, the resistance remains approximately constant for different values of current. **This means that the V/I = constant (R).**

Example

The current through a resistor is 0.2 amps when the voltage across it is 6 volts. Calculate the resistance.

$$\text{resistance} = \frac{\text{voltage}}{\text{current}}$$

$$= \frac{6}{0.2}$$

$$= 30\Omega$$

Variable Resistors

Variable resistors can have their resistance changed by altering the length of wire in the resistor. The longer the wire, the greater the resistance. Variable resistors are used in volume or brightness controls on televisions, dimmer switches on lights, thermostats etc.

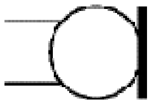
Input Devices

An **input device** is one which changes some other form of energy into electrical energy so that the electrical signal produced can be processed by the electronic system.

Microphone

A microphone changes **sound energy** into **electrical energy**. It is used as an input device in radio **transmitters and karaoke machines.**

Mobile phone microphones.

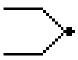


microphone symbol

Thermocouple

A thermocouple is a device, which can produce a small voltage when it is heated. It can be made by twisting together two wires made from different metals e.g. iron and copper. By heating such a junction, **heat** is changed to **electrical energy**.

Thermocouples measure a wide range of temperatures.

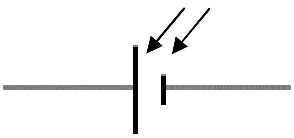


thermocouple symbol

Thermocouples can be used to measure very high temperatures.

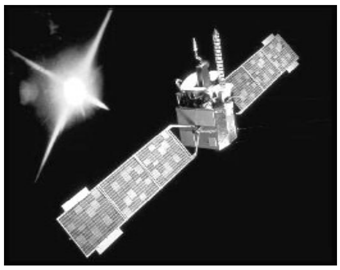
Solar Cell

A solar cell is made of a substance that produces a voltage when light falls on it, i.e. it transforms **light energy** to **electrical energy**.



solar cell symbol

Banks of solar cells are used to produce electrical energy to power instruments in space crafts. They are also used in photographic light meters to measure light intensity. As the light gets brighter, the output voltage increases.



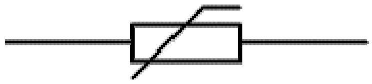
Solar cells on a satellite.

Thermistors are used in cars to monitor engine temperature

The following input devices are environmentally sensitive devices. The conditions in which they are placed are of importance.

Thermistor

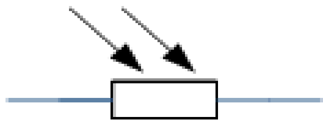
A ***thermistor*** is made of a substance which has a resistance that changes as it is heated or cooled. **The temperature changes the resistance of the thermistor.** Thermistors are devices which can be used to measure temperatures over a wide range.


thermistor symbol


LDRs are used in garden lighting to ensure the lights come on when it is dark.

Light Dependent Resistor (LDR)

A ***light dependent resistor*** is made of a substance which has a resistance which changes as the light level changes. **The resistance of an LDR decreases as the light gets brighter.** This makes it very useful for a range of devices like smoke detectors, automatic lighting controls and burglar alarm systems.


LDR symbol

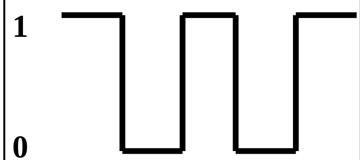
Input Devices and Logic Levels

Input Device	Logic level 0	Logic level 1 when
Microphone	No sound	sound
Thermocouple	cold	warm
Solar cell	dark	light
Thermistor	cold	warm
LDR	dark	light


The first iPods stored no more than 5000 songs.

Output Devices

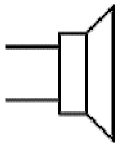
An **output device** is one which changes electrical energy, from the process part of an electronic system, into some other useful form of energy.



This is a digital signal, it is displayed as a series of 1s and 0s.

Loudspeaker

A loudspeaker changes **electrical energy** into **sound energy**. It can be used as an output device in radios, TVs and iPods.



loudspeaker symbol

Electric Motor

An electric motor changes **electrical energy** into **kinetic energy.** Electric motors are used in a number of devices such as fans, power tools and disk drives.

motor symbol

A solenoid is used in electromagnetic locks.

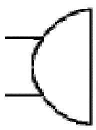
Solenoid

A solenoid is a device that uses an electromagnet to produce movement in a straight line. **Electrical energy** changes to **kinetic energy** in a solenoid. Solenoids are used in the central locking systems of a car and washing machine doors.

solenoid symbol

Buzzer

A buzzer changes **electrical energy** into **sound energy**. Buzzers are used in a number of devices such as smoke detectors and microwave ovens.



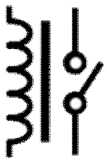
buzzer symbol

Buzzers are used a lot on television shows.

An electromagnetic relay.

Relay

A relay is a switch, which is operated by an electromagnet. When an electric signal is passed through the electromagnet, the switch in the relay can be switched on or off. **Electrical energy** changes to **kinetic energy** in a relay. Relays can be used in air conditioning controls or heating controls (thermostats) and lifts.

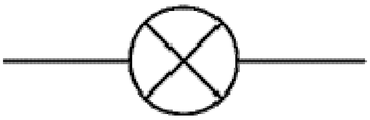


relay symbol

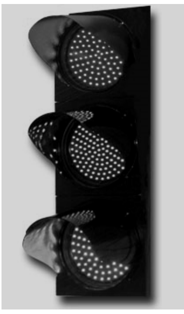
LEDs are replacing bulbs in car headlights.

Bulbs

A standard bulb is made of a very thin strand of wire (the filament) sealed inside a glass bulb. The wire glows white hot when there is a large enough electric current in it. The bulb changes **electrical energy** into **heat** and **light energy.** Bulbs are used in torches and lamps.



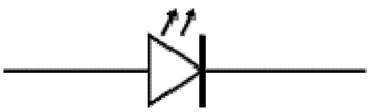
bulb symbol



LEDs are being put to use in traffic lights

Light Emitting Diodes (LEDs)

LEDs are made from semiconductor material. They convert **electrical energy** to **light energy** when they are placed in a circuit correctly. LEDs are used to indicate when something is on, off or on standby, such as a TV or computer. They are now being used widely for lighting as they are efficient.



LED symbol

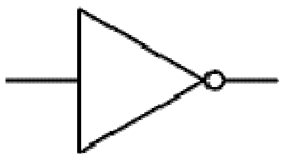
Output Devices and Logic Levels

Output Device	When logic level 0	When logic level 1
Loudspeaker	No sound	Sound given out
Electric Motor	No movement	Motor rotates
Buzzer	No sound	Buzzes
Solenoid	No movement	Plunger moves
Relay	No movement	Switch closes
Bulb	No light	Lights up
LED	No light	Lights up

Logic Gates

Logic Gates are part of a family of electronic devices in which the output signals are controlled by the states of the input signal(s). Logic gates are digital devices, which means that they use the logic levels (0 and 1). Each gate has a **truth table** which shows how the output of the gate varies with the input(s). The three common gates are:-

The NOT-gate

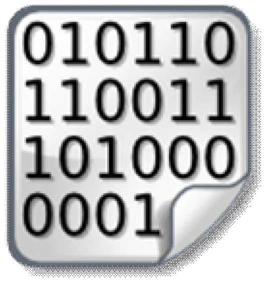


NOT-gate symbol

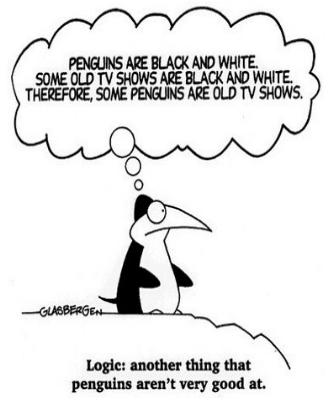
Input	Output
0	1
1	0

Truth Table for a NOT-gate

From the truth table of the NOT-gate it is clear that the output of the NOT-gate is 'not' the same as the input. The NOT-gate is also known as an **inverter** since it inverts the input signal.

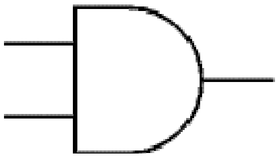


Digital electronics use binary code (0s and 1s) to store information.



Microchips contain thousands of logic gates.

The AND-gate



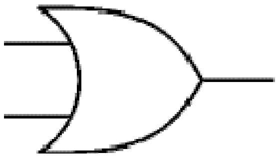
AND-gate symbol

Input A	Input B	Output
0	0	0
0	1	0
1	0	0
1	1	1

Truth Table for an AND-gate

From the truth table of the AND-gate it is clear that the output of the AND-gate is logic 1 when both input A and input B are at logic 1.

The OR-gate



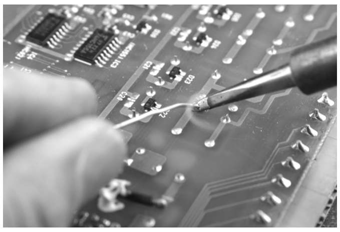
OR-gate symbol

Input A	Input B	Output
0	0	0
0	1	1
1	0	1
1	1	1

Truth Table for an OR-gate

From the truth table of the OR-gate it is clear that the output of the OR-gate is logic 1 when either input A or input B is at logic 1.

The wind up radio enables people in remote areas without electricity to receive up to date information.



Scotland continues to manufacture and export electronic systems to the world.

The worlds first personal calculator, made in 1972.

Combining Logic Gates and Devices

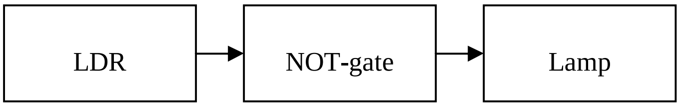
Input devices, logic gates and output devices can be joined together to form electronic systems (as you know).

Below two simple electronic systems are considered :-

1. A security lamp - a light that automatically switches on when it gets dark.

Think first. The input will come from a light sensor, an LDR. When the LDR is in the dark its logic level is 0.
Therefore a NOT-gate is necessary to invert the logic level from 0 to 1.
This output from the NOT-gate will allow the output device (a lamp) to work.

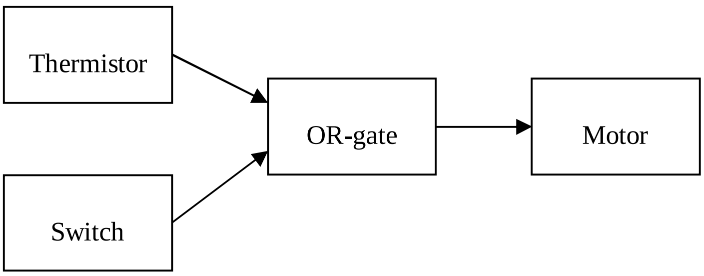
Block Diagram



2. A temperature control for an office - an air conditioning unit that switches on when it gets too warm or switches on manually.

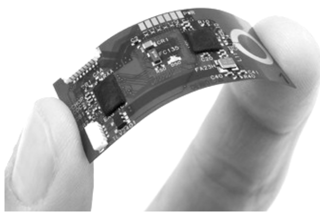
The inputs will be a temperature sensor, a thermistor, and a switch. The thermistor when warm has a logic level of 1 and the switch can be operated by any person in the office to give a logic level of 1. Therefore an OR-gate is suitable as it will give an output of 1 when either input is 1. The output from the OR-gate will work a motor in the air conditioning unit.

Block Diagram



Infra red security lamps are used for specialised surveillance.

Thermostats can be used to control heating or air conditioning units.



Nanotechnology is one of the most active areas of scientific research.

Why are nails pointed?

Why do camels have big feet?

Why do tractors have big wheels?

Kinetic Theory

Pressure

Pressure on a surface is defined as the force per unit area.
Hence :

$$P = \frac{F}{A}$$

Where: P is the pressure measured in Pascals (Pa)
F is the force measured in Newtons
A is the area measure in square metres (m^2)

1 Pascal is equivalent to 1 Newton per square metre; i.e. 1 Pa = 1 Nm^{-2}

Example

Calculate the pressure exerted on the ground by a truck of weight 16 000 N if each wheel has an area of 0.02 m^2 in contact with the ground.

$A = 4 \times 0.02 = 0.08\ m^2$
$W = 16\,000\ N$

$$P = \frac{F}{A}$$

$$= \frac{16\,000}{0.08}$$

$$= 200\,000\ Pa$$

Kinetic Theory of Gases

The kinetic theory tries to explain the behaviour of gases using a model. The model considers a gas to be composed of a large number of very small particles which are far apart and which move randomly at high speeds, colliding with and bouncing off everything they meet.

Volume
The volume of a gas is taken as the volume of the container. The gas particles move about throughout the container. However the volume occupied by the gas particles themselves is very small compared to the volume of the container.

Temperature
The temperature of a gas depends on the kinetic energy of the gas particles. The faster the particles move, the greater their kinetic energy and the higher the temperature.

Pressure
The pressure of a gas is caused by the particles colliding with the walls of the container. The more frequent these collisions or the more violent these collisions, the greater the pressure will be.

Gas Laws and the Kinetic Theory of Gases

Pressure and Volume (constant mass and temperature)

Consider a volume, V, of a gas at a pressure, P. If the volume of the container is reduced without a change in temperature, the particles of the gas will hit the walls of the container more often. This will produce a larger force on the container walls. The area of the container walls will also reduce with volume. As volume decreases, then the force increases and area decreases resulting in an increase in pressure.

Pressure and Temperature (constant mass and volume)

Consider a gas at a pressure, P and temperature, T. If the temperature of the gas is increased, the kinetic energy and hence the speed of the particles of the gas will increase. The particles collide with the container walls more violently and more often. This will produce a larger force on the container walls. Thus resulting in an increase in pressure as the temperature increases.

Volume and Temperature (constant mass and pressure)

Consider a volume, V of a gas at a temperature, T. If the temperature of the gas is increased, the kinetic energy and hence the speed of the particles of the gas increases. If the volume was to remain constant, an increase in pressure would result as explained above. If the pressure is to remain constant, then the volume of the gas must increase to increase the area of the container walls that the increased force is acting on. As the temperature increases the volume of the container increases if the pressure remains constant.

Balloons can be useful when thinking about kinetic theory.

Why should you not check tyre pressure after a long Journey?

Why is maintaining cabin pressure important on an plane?