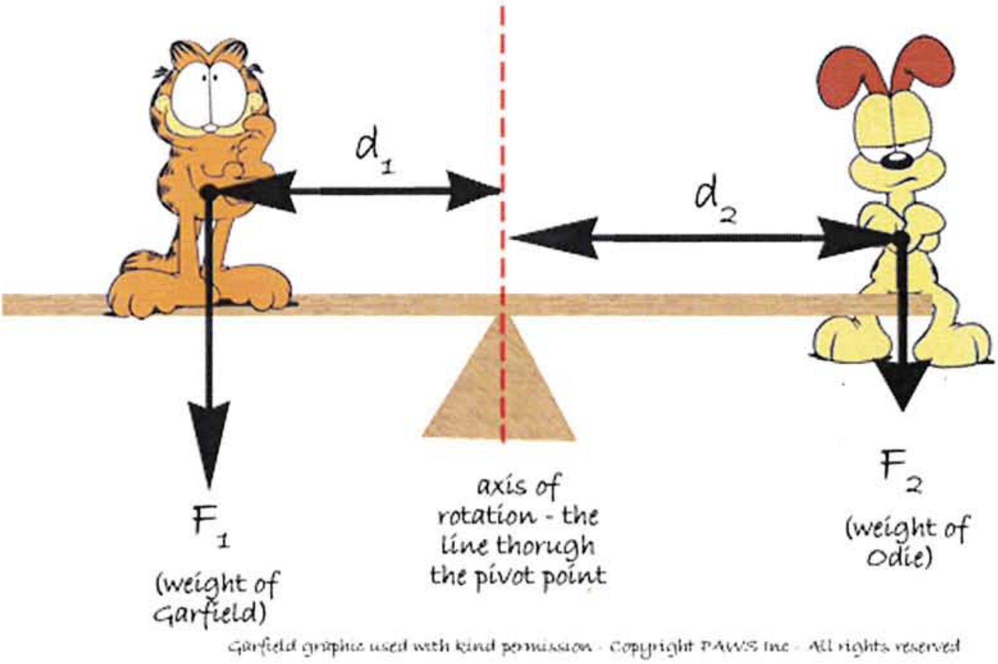
Harris Academy Greenwich

Science

Triple Physics (P3)

Revision Pack



Student Name: ____________________________

Teacher Name: ____________________________

1 Moments

Turning Effects

Trying to unscrew a nut requires a spanner. It is common knowledge that a longer spanner makes it easier – this is because *less force* is required to pull the nut out. Unscrewing a nut is an example of a **turning effect**. The turning effect of the force is called the **moment**, which can be increased by:

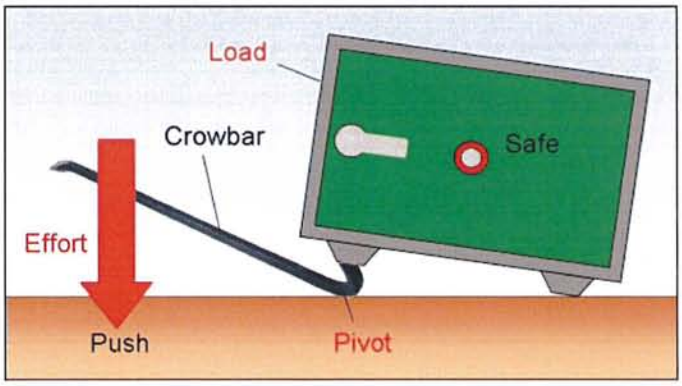
- increasing the size of the force
- using a longer instrument

You can work out the moment using this equation:

moment	=	force	x	perpendicular distance from pivot
(newton metres, Nm)		(newtons, N)		(metres, m)

Levers

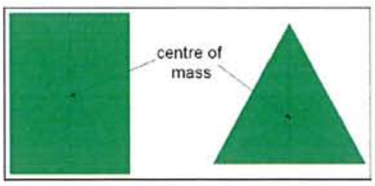
The diagram below shows a crowbar being used to lift a safe



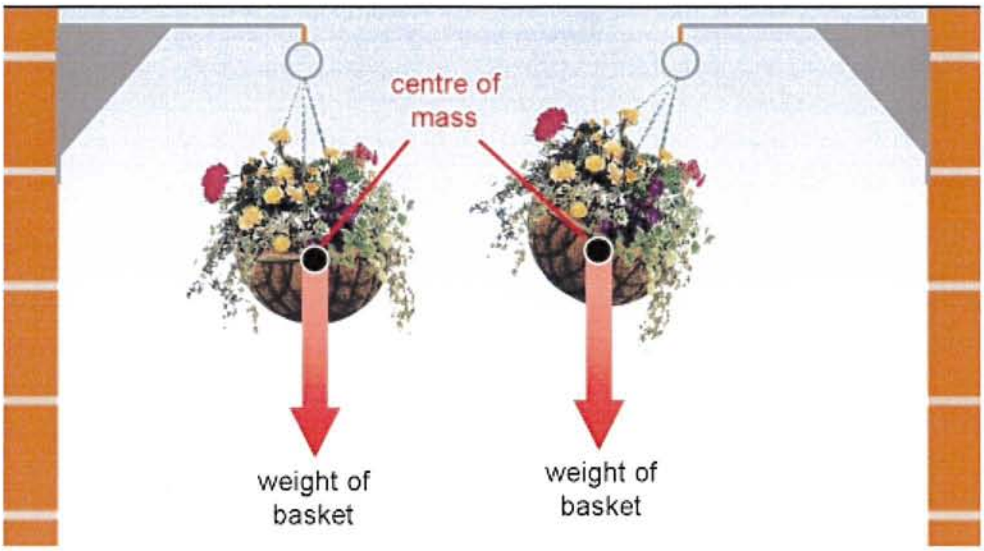
Imagine that someone is pushing down on that crowbar, and that is what causes the push. The push is the force applied by a person, which we call **effort**, when trying to lift objects – the **load** - around a **pivot** (the point at which the crowbar turns).

Centre of Mass

We say that there is a point of an object where we can think of it as though the weight acts at that single point. We call this the **centre of mass** or **centre of gravity**. The centre of mass is the point of an object where its mass may be concentrated.



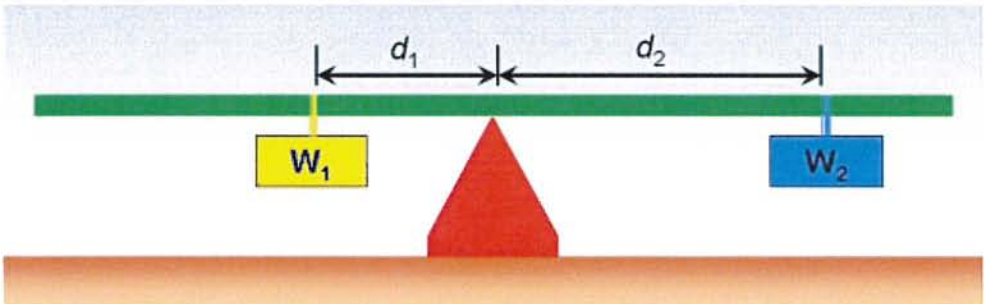
For a symmetrical object, the centre of mass lies along the axis of symmetry. When an object has several axes of symmetry, it is where the lines meet.



A hanging object rests with its centre of mass directly below the point of suspension. This means that the object is said to be in **equilibrium**. Because the centre of mass is directly below the point of suspension, no turning effect is exerted by the weight, as shown with the left hanging flower basket. When an object is moved from its original position and released, it will swing back into its equilibrium position. This is because the weight of the object causes a turning effect on the object to move it back to that position, as shown with the right hanging flower basket. The point at which it is not in equilibrium is called **non-equilibrium**.

Balanced Moments

A moment in balance does not necessarily have to be with the pivot around the centre of the object. However, when balancing moments around an object we say they do. Look at the diagram below, showing a balanced moment:

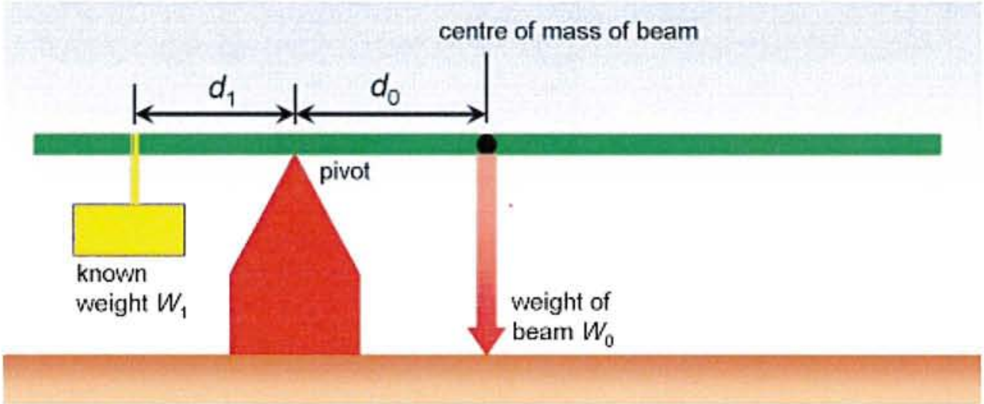


Just by looking at the diagram you can tell the moment is in balance. You can also clearly see that the distances are different – which means that to be in balance, the weights bust also be different. Because it is in balance, we know that: W1 x D1 = W2 x D2.

This seesaw action is an example of the **Principle of Moments**. This states that for an object in equilibrium:

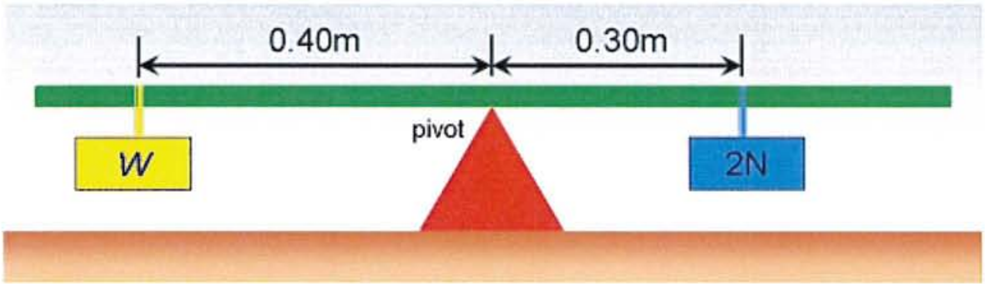
sum of all clockwise moments about a point = sum of all anticlockwise moments

We can use (W1)(D1) = (W2)(D2) to do calculations involving moments. For example, if we are given the following diagram, where the pivot is not at the centre of mass:



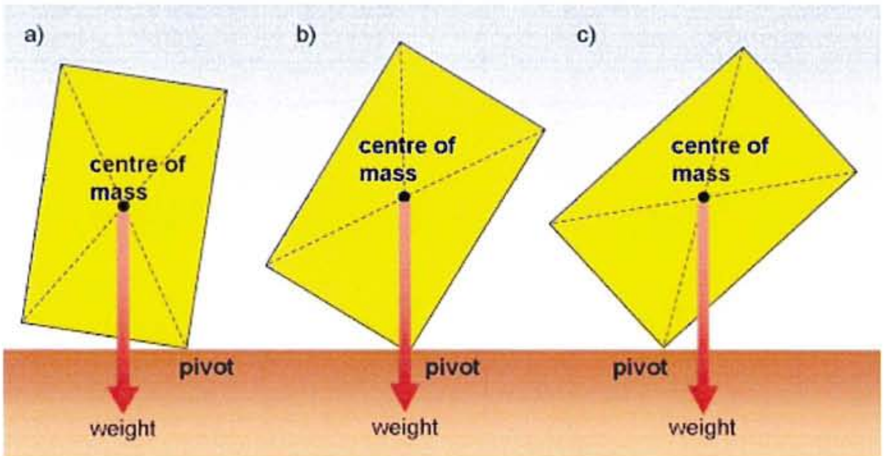
We can calculate W0 if we know W1 and d1 and d0. Take W1 as 4.0N, d1 as 0.20m and d0 as 0.25m. Rearranging the equation of (W1)(d1) = (W0)(d0), we get:
W0 = (W1)(d1) ÷ d0 = (4.0N x 0.2m) ÷ 0.25m = 3.2N

Of course we can perform the same calculations when the centre of mass holds the pivot. Try to calculate the unknown value in the following diagram:



Stability

Objects have a certain amount of **stability**, where they can withstand a certain amount of **tilting** before they **topple** over. The diagram below shows three stages of a brick's tilt:



- If you tilt the brick slightly (diagram a) and then release it, the turning effect from the brick's weight returns it to its upright position
- If you tilt the brick a bit further (diagram b), you will find that there is one position that it can remain balanced on one edge. This happens when the centre of mass is directly above the edge on which it is balancing – there is no turning effect exerted in this position
- If you tilt the brick even more (diagram c), it will topple over upon release. This happens because the line of action of the weight is "outside the base" of the object (in the diagram you can see this because the arrow showing weight rests outside the two lines at the base of the rectangle)

A lot of objects can topple over very easily, which is why some are manufactured especially to prevent toppling over. Examples include **tractors** - think about how wide apart their wheels are and how low the engines are kept. Because the centre of mass is in the engine, it is kept low so that the tractor has to tilt an awful lot for the line of action of the weight to fall outside the base – and even if it did, it is pushed back further by the fact the wheels are incredibly distant to each other. Safety is another huge factor in toppling – take **buses** and **coaches** for example. They have to go through tilt-tests before they are allowed on the road to see how much they can tilt before toppling over. These test are important because it has to be able to drive along hilly roads and turn through sharp corners.

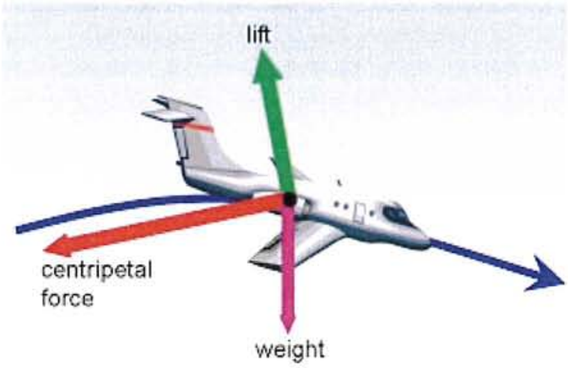
Circular Motion

An object attached to a piece of string, or similar material, when whirled round, will move in a circular direction in the air. A good example of this is the hammer throw. The arrows on the image below show this example of **circular motion**:

For an object moving in a circle at a constant speed at any instant:

- its velocity is directed along a tangent to the circle of direction
- the velocity constantly changes direction as it moves around the circle
- the change of velocity is towards the centre of the circle

Therefore, the object is constantly accelerating towards the centre of the circle. So the force on the object act towards the centre of the circle. This force that acts towards is a **resultant force** (see Physics P2 section on Forces and Motion) called the **centripetal force**, because it *always* acts towards the centre of the circle.



The centripetal force of an aircraft is the resultant force of the two other forces acting on the aircraft: the weight of the aircraft and the lift of the aircraft.

Likewise, the centripetal force of a car driving around a roundabout comes from the friction between the tyres and the road.

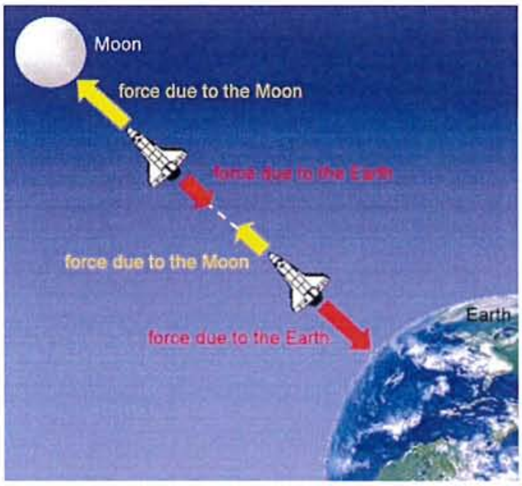
There are certain factors affecting the centripetal force. If we wanted to know how much force is needed to keep an object moving in a circle, we could use a radio-controlled car – if it goes too fast, it skids off in a straight line, so when speed increases, centripetal force has to increase. If the circle is too small, the car will still skid off, so again, the centripetal force has to go up when the radius of the circle decreases.

Say we wanted to know how much does the force depend on the mass of the moving object. We could try swinging a ball of blue tac attached to a piece of string in the air, and then a larger ball, twice the size. To keep the larger one going at the same speed (provided it is still the same radius), a larger force is required – hence, the greater the mass, the greater the centripetal force.

Gravitational Forces

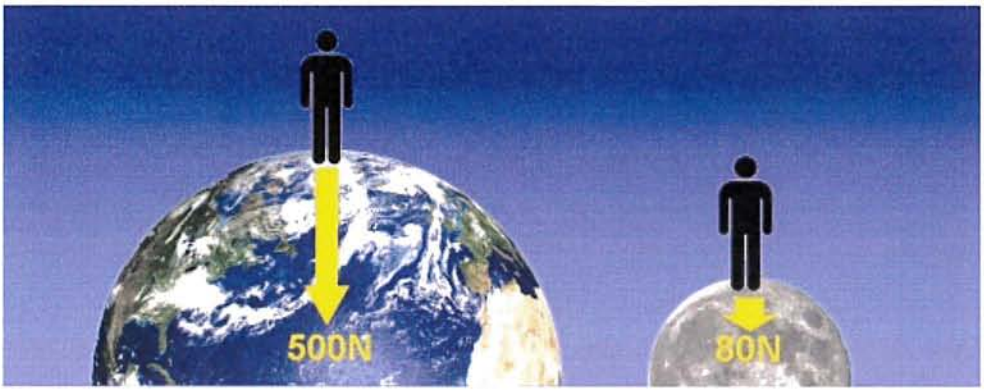
Any two objects exert a gravitational force on each other. **Isaac Newton** discovered gravity, and he said that the force of gravity between any two objects:

- is an **attractive** force
- gets bigger with the mass of each object
- gets smaller with greater distance between the two objects



When a space probe leaves Earth and heads towards the Moon, the force of gravity acting on it due to the Earth decreases as it moves away, and due to the Moon increases as it moves further towards the Moon.

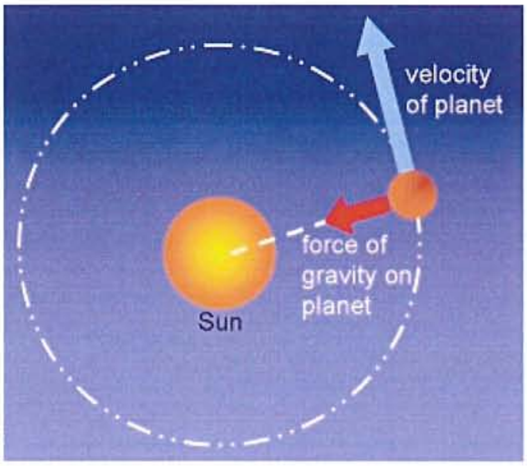
The **gravitational field strength** of the Earth at its surface is 10N/kg. So the force of gravity on a 50kg person on the Earth is 500N. The Moon's is 1.6N/kg. So the force of gravity on a 50kg person on the Moon is 80N.



The reason for this is because the Earth's mass is so much greater that it exerts a greater force on the surface than the Moon does.

Planetary Orbiting

The Moon **orbits** the Earth in a circular orbit, and the Earth, along with the other planets, orbits the Sun in a slightly squashed circle – an **elliptical orbit**. In each case, an object orbits an object far larger than itself – and the *centripetal force* is present because of the gravitational forces of attraction between the smaller object and the larger object.



To stay in orbit at a particular distance, the planet must travel at a particular speed around the Sun. If the speed is too low it will spiral into the Sun. If the speed is too high, it will spin out of orbit away from the Sun. The further away from the Sun a planet is, the lower its speed as it moves around the Sun, because the force of gravity is weaker. Therefore, the further the planet is from the Sun, the longer one orbit takes.

Satellite Orbiting

Global positioning satellites (**GPS**) send out signals that are used by a receiver to pinpoint someone's position. We often use these in cars so we know exactly where we are and in which direction (and therefore where,) we are going. Satellites are launched either from the ground on Earth or from a space vehicle.

If a satellite's speed is too low, it will fall to the ground. If its initial (launch) speed is too high, it will fly off into space. There is therefore a "correct" speed, the "in between" marker, which will let it orbit the Earth. The same rules apply, the further away a satellite is from the

Earth, the slower the travelling speed. One complete orbit of a satellite around Earth is called a **period**.

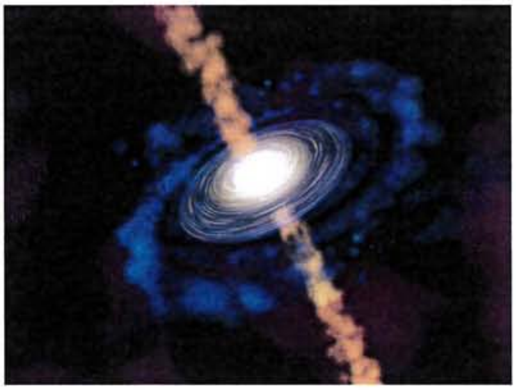
We have several uses for satellites in modern life:

1. There are **communication satellites** which orbit the Earth at a particular height above the equator so that they have a period of 24 hours, and because they travel at the same speed as the Earth spins on its axis, the satellite remains above the same place of the Earth's surface constantly. We call this orbit **geostationary**. These orbits tend to be around 36,000km above the Earth – because the force of gravity at that height keeps the satellite moving at such a speed that a 24 hour orbit takes place
2. And there are **monitoring satellites** fitted with TV cameras pointing at the Earth. For these we have many uses, including weather forecasting, police and military surveillance and environmental observations. These are much lower orbits – purely so that we can see as much detail of the Earth as possible. One period of these satellites takes between two or three hours, and their orbits go past both the Poles, so they monitor the entire Earth all day long

2 Space

Introduction to Galaxies

Around 13 billion years ago, the **Universe** was created by **the Big Bang**. The Big Bang created space, radiation and time, and at first, our Universe was just a hot glowing ball of radiation and matter – but as it expanded, its temperature fell and it is now cold and dark, except for certain hot spots we call **stars**. The stars we can see at night are all in our **Milky Way galaxy** (our home **galaxy**). The **Sun** is just one of billions of stars in the Milky Way galaxy, which we can see, along with others using a telescope – as well as certain other individual stars in other galaxies. We know that there are billions of different galaxies, all with empty space in between them. Light has taken billions of years to finally reach us from distant galaxies.



The photograph here on the left shows **Andromeda**, the nearest large galaxy to the Milky Way galaxy. The photograph on the right is a *protostar* (see later on).

The Universe became transparent as it expanded, and radiation passed through the empty space between its atoms. This is the stage at which **background microwave radiation** was created – we call this the **Dark Age** of the Universe. Over a few billion years, the Universe was just a dark empty space of hydrogen and helium – but then stars and galaxies formed, lighting up the Universe.

Gravity in Space

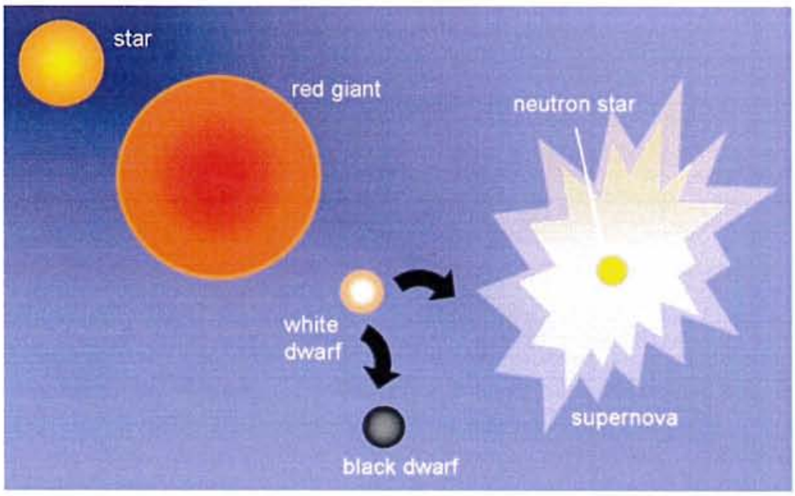
Although uncharged atoms don't repel each other – they can attract each other. During the Dark Age, the force of gravitational attraction was at work without any opposition from repulsive forces. As the Universe expanded, denser parts became more common, and gravity pulled more and more matter into the denser parts – forming larger clumps of space matter. Eventually, the force of gravity turned the clumps into stars and galaxies. A few billion years after the Big Bang, the Dark Age ended – stars had lit up the Universe.

Star Birth, Life and Death

A star forms from a cloud of gas and dust. This matter joins together using its own gravitational force – and as the clouds merge together, it becomes denser and denser – until it is a **protostar** (a star in the making). A protostar becomes denser and gets hotter until the point where it becomes hot enough for the hydrogen nuclei (and nuclei of other light elements) to **fuse** together. Energy is released in this process, causing the **core** to get hotter, bigger and brighter and eventually it begins to shine – a **star** has been born.

Due to hydrogen **fusion** in the core, stars (including the Sun) radiate energy. This is the main part of a star's life, as it can continue to do it for billions of years until it runs out of hydrogen nuclei to fuse together. The fusion process is able to continually happen because energy is released from fusion – and this energy keeps the core hot for more fusion to occur, and so on, and so forth. Radiation flows out steadily from the core in all directions. The force of gravity which makes the star core contract is equally balanced out by the pressure of radiation from its core. These forces stay balanced until most of the hydrogen nuclei have been fused together.

When a star runs out of hydrogen nuclei, it swells out. As it swells, it cools down and turns red – it has become a **red giant**. At this stage, helium and other light elements fuse together to form heavier, denser elements. When there are no more light elements in the core, fusion halts. No more radiation is released, and the star collapses in on itself. During collapsing, it heats up again, and turns from red, to yellow to white – it becomes a **white dwarf**. This is much smaller, but far hotter and denser than ever before. Small stars, such as the Sun, end their lives in this way; however, there are bigger stars which go out with a bang – literally. Their collapse continues past the white dwarf stage until the process reverses and a cataclysmic explosion takes place, called a **supernova**. This is so powerful it can outshine a galaxy for several weeks.



After the white dwarf stage, if the star does not proceed to be a supernova – it becomes a **black dwarf**. This is when it has a *low mass, high mass* stars go on to explode as supernovas. So remember only big stars become supernovas. But what happens after supernova? The explosion from a supernova compresses the core of the star into a **neutron star**, which is an extremely dense object, consisting only of neutrons. To give you a rough idea of how dense one of these is, every cubic centimetre of the material would weigh just over ton! And then it continues! If the neutron star is big enough, it turns into a **black hole**. The gravitational field strength of one of these is so immense nothing can escape it – not even light, or any other form of electromagnetic radiation for that matter.

There is a galaxy called the **M87 Galaxy** which spins so fast at its centre that it is thought to contain a black hole with a mass more than one billion times as heavy as our Sun.

To summarise:
A **low mass star** goes from protostar to star to red giant to white dwarf and then onto being a black dwarf. A **high mass star** goes from protostar to star to red giant to white dwarf to supernova, then neutron star, and then a black hole if it has a sufficient mass.

Formation of Chemical Elements in Space

The life of a star involves a lot of nuclear fusion, but how is this possible without the nuclear part? The chemical elements then, and the ones we have now must have come from somewhere. The light elements formed as a result of fusion in the stars. Stars like our Sun fuse hydrogen nuclei (basically protons) into other elements with small nuclei, namely helium and sometimes carbon. Upon entering red giant stage, it fuses helium and other small nuclei elements into larger nuclei, but once it gets to iron, nuclear fusion cannot continue because too much energy is needed to fuse iron.

Heavy elements only form when the big stars collapse and explode as supernova. This happens because the immense pressure of the collapsing causes smaller nuclei to fuse into larger nuclei – but this time larger than iron. The explosion scatters the star into space, and the debris from the supernova contains every known element – from the small, light ones, to the heaviest ones. Eventually a new star will form when gravity brings the debris closer together.

Planets also form from gravity bringing together the debris from exploded supernova. Likewise, this means that planets are also made from all the known elements. The heaviest of the elements we know is **uranium**, with a radioactive half-life of 4,500 million years. The presence of such an element is *proof* that the Earth must have formed from the remnants of an exploded supernova long ago.

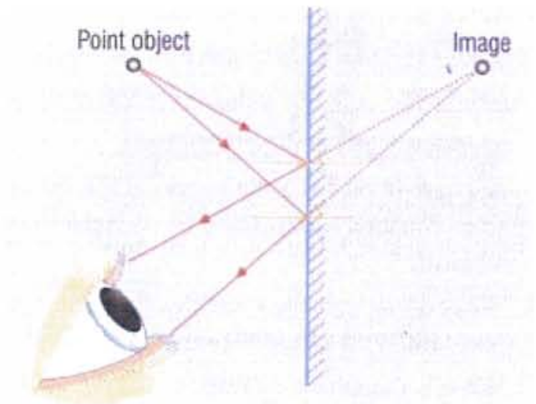
We are still trying to figure out as to whether or not there can be, and more importantly if there is, life in outer space other than our own. Here is what we are doing so far:

- **space probes** have tested the rocks, soil and atmosphere on Mars to test for microbes and chemicals which might suggest life ever was there or still is
- the **Search for Extra-Terrestrial Intelligence** (**SETI**) has been using radio telescopes for more than forty years looking for technological signals from life forms as developed as ourselves sending them out – although we have found nothing yet from this

3 Light & Sound

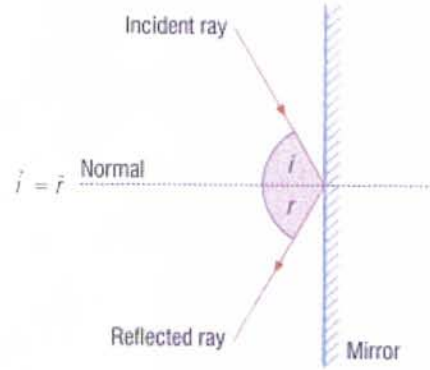
Light Reflection

There are a number of different types of mirror. A **plane mirror** (or flat mirror) will show you an exact **mirror image** of yourself if you look into it. Some mirrors bend *outwards*, these are called **convex mirrors** - if you look in one of these you see yourself being really tall and thin – like at a funfair's Hall of Mirrors. Similarly, looking into a **concave mirror** which folds *inwards* will present a shortened, fatter image than the true object.



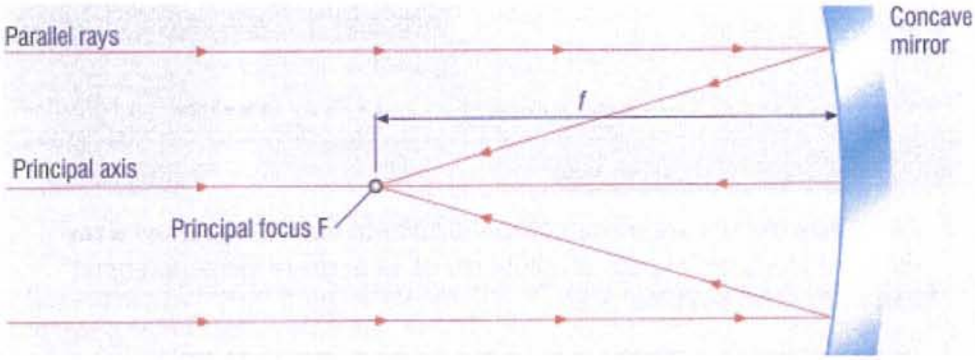
An image seen in a mirror is there because of **reflection of light**. The diagram shows how light reflection works. There are two angles against a ray of light in reflection. You have the angle of **incidence** and the angle of reflection. The line perpendicular to the mirror is called the **normal.** The angle between the incident ray and normal is the angle of incidence. The angle between the reflected ray and normal is the angle of reflection. These are equal for any ray reflected by a mirror.

The image being reflected in the first diagram above is a **virtual image**. When looking at a mirror image, the light rays that reflect off the mirror into your eye appear to come from the image. This virtual image cannot be projected onto a screen like at the cinema, unlike a **real image**. A real image can because it is formed by focusing light rays onto a screen.

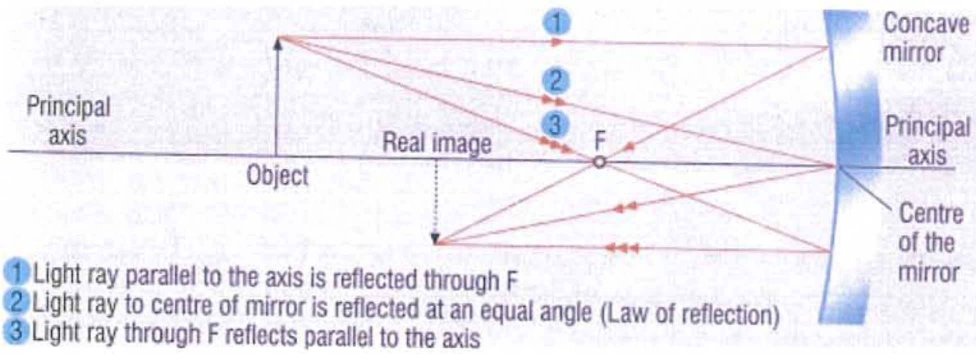


Concave & Convex Mirrors

A **concave mirror** folds inward. For a distant object, the light rays are parallel when they reach the mirror, as shown. They are then focused to a **principal focus** (or **focal point**), ***F***, of the mirror. A real image of the object is formed. The distance between the mirror and the principal focus is the **focal length**, ***f***, of the mirror.



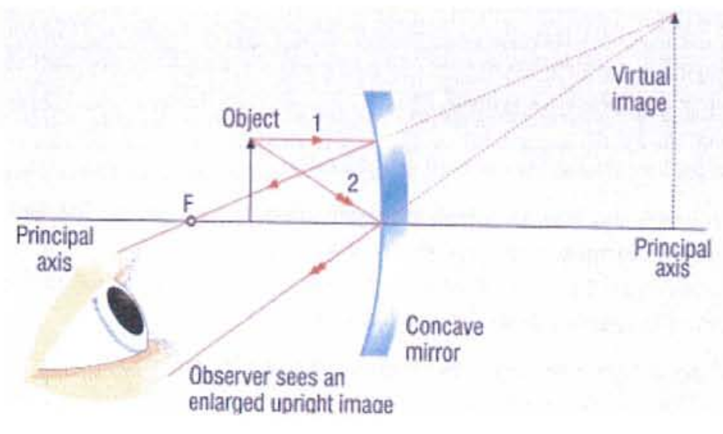
If an object is beyond the principal focus, an *inverted image* is formed (appears upside-down) by the reflected rays. The position and size of the image depends on the distance from the object to the mirror. The diagram below shows how to use a ray diagram to locate the image:



The light rays from the tip of the object are used to locate the tip of the image. The **magnification** of the image is:

image height ÷ object height

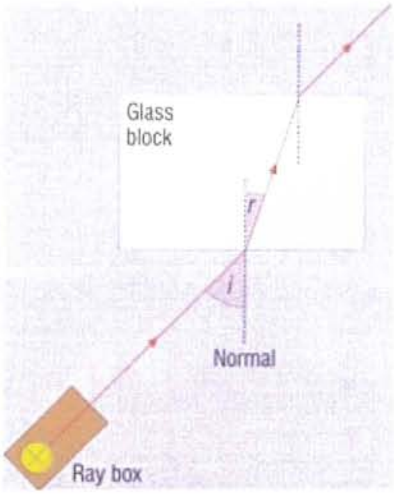
When the object is between the focal point and the mirror, the reflected rays form an upright virtual image. The diagram below shows how the image is formed using *three* construction rays. The image is magnified and behind the mirror:



A **convex mirror** folds outwards. They are used for rear-view mirrors in cars. It gives drivers a much wider view because the light reflects outwards, not inwards. This enables them to see more than an 180° plane, which is very useful.

Light Refraction

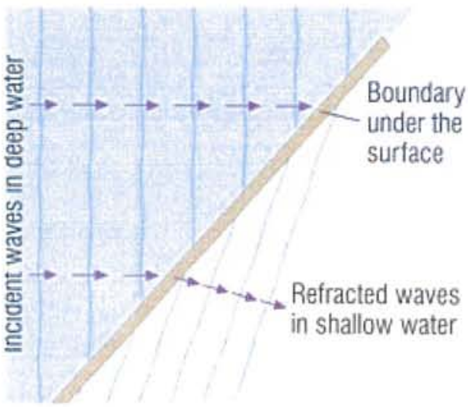
The change of direction in light rays is called light **refraction**.



The diagram shows a simple experiment using a ray box and a glass block, which displays refraction of light. What happens is:

- there will be no change in direction if the light ray is along the normal
- as the light ray travels from air to glass, it bends towards the normal, so the angle of refraction, *r*, is smaller than the angle of incidence, *i*
- as the light ray travels from glass to air, it bends away from the normal, so angle *r* is larger than angle *i*

Refraction applies to all types of wave, including light and sound. The diagram below demonstrates refraction using waves of water in a ripple tank:



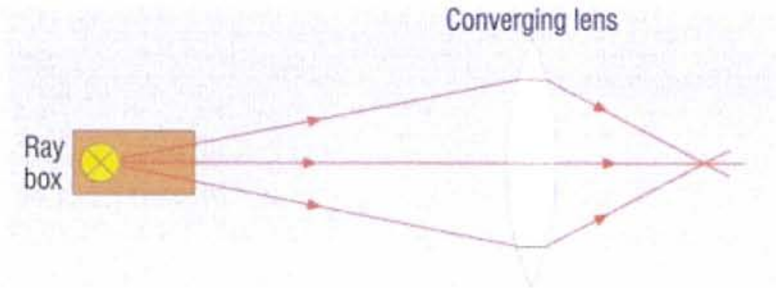
A glass plate is submerged in the ripple tank. The water above the glass tank is shallower than the water in the rest of the tank. Waves are slower in shallow water than in deep water. Because they change speed as they cross the boundary between shallow and deep, they have to change direction:

- towards the normal as they go from deep to shallow and slow down
- away from the normal as they go from shallow to deep and speed up

Light travels slower in glass than in air. When a light ray travels from air to glass, it refracts towards the normal because it slows down upon entering the glass block. When a light ray travels from glass to air, it refracts away from the normal because it speeds up upon leaving the glass.

Lenses

A **lens** works by changing the direction of light passing through it. The diagram below shows how a lens refracts the rays so that they all meet as a point.

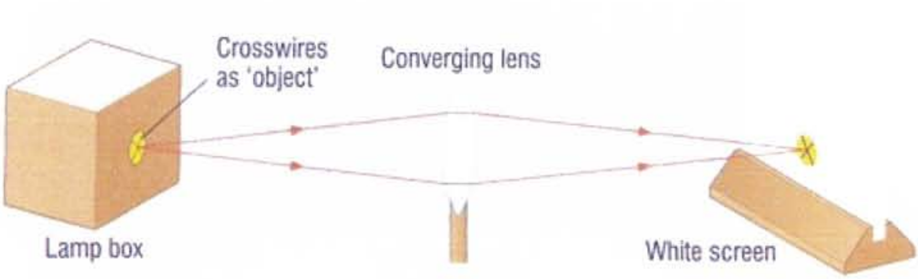


Different lens shapes can be tested using:

- a **converging lens** makes parallel rays *converge* to a **focus**, where the point the parallel rays are focused is the principal focus (or focal point) of the lens
- a **diverging lens** makes parallel rays *diverge* (or spread out), where the point the parallel rays appear to originate from is the principal focus of the lens

Again, the distance between the centre of the lens to the principal focus (in both lens types) is the focal length.

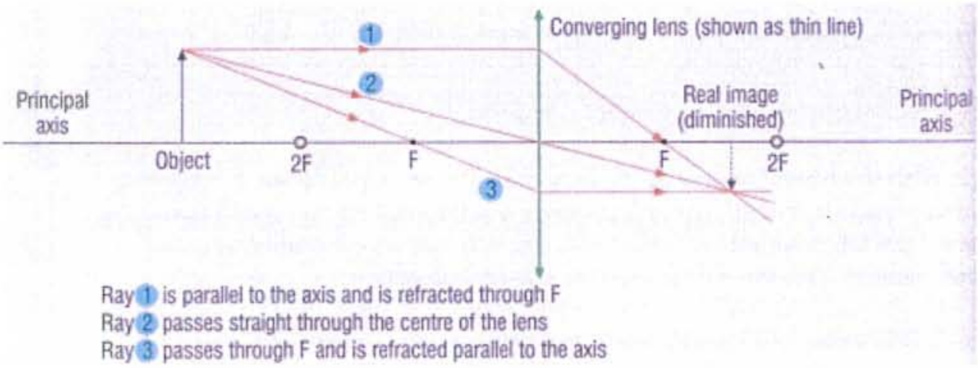
Look at the below diagram, which shows a lens being used to project an image onto a white screen:



When the object is at a distance from the lens which is further than the principal focus, the position of the screen has to be adjusted until a clear image of the object is seen on the screen. The image is **real** because the image is formed where the light rays meet. When the object is a long distance away from the lens, the image is formed at the principal focus. If the object is moved nearer towards the lens and the principal focus, the white screen must be moved further from the lens to see a clear image. The nearer the object is to the lens, the larger the image.

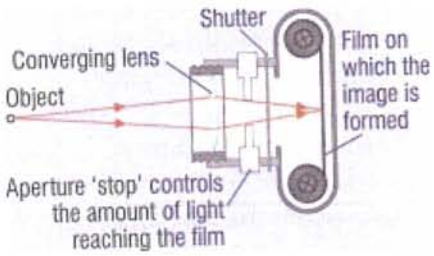
When the object is nearer to the lens than the principal focus, a *magnified* **virtual** image is formed, but you can only see the image when you look into the lens from the other side to the object. The lens acts as a **magnifying glass** in this situation.

Formation of a real image by a converging lens -
The object must be beyond the principal focus, *F*, of the lens. The image formed is on the other side of the lens to the object.

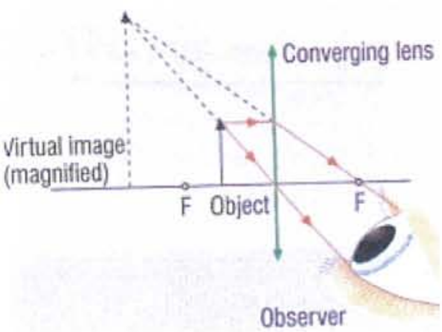


As the diagram shows, three construction rays are used to locate the image, which is real, **inverted** and smaller than the object. Notice:

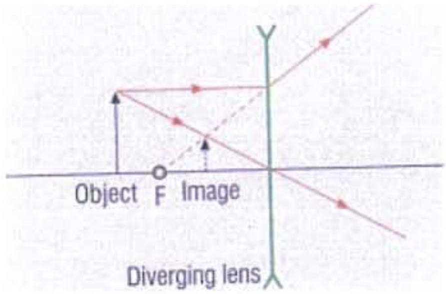
- ray 1 is refracted through *F* after the lens, because before the lens, the ray is parallel to the principal axis
- ray 2 passes through the centre of the lens and does not change direction
- ray 3 passes through *F*, the focus, before the lens, and so after passing through the lens is refracted to be parallel to the principal axis



The image is smaller because the distance of the object from the lens is more than twice the focal length of the lens. This is how a camera works, as shown in the diagram to the left. The image is formed on the film, using a converging lens. For a distant object, the distance between the lens and the film must be equal to the focal length of the lens.



Formation of a virtual image by a converging lens -
The object must be between the lens and its principal focus. The image formed is on the same side as the object, and is upright and larger than the real object. The image can only be seen by looking at it through the lens, as the diagram shows. This is how a magnifying glass works. The diagram shows how the image is smaller than the actual object and how it is formed.



Formation of a virtual image by a diverging lens - The image formed by a diverging lens is also always upright and virtual, but, it is smaller than the object. The diagram shows the formation of a diverging lens image. For this reason, a diverging lens would not be of any use as a magnifying glass , using a diverging lens will produce a smaller image than the object.

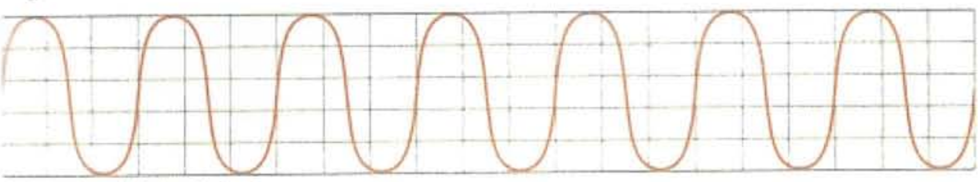
Sound

Any object which vibrates sends out sound waves through the air, and vibrate your eardrums so you hear sound. Sound waves cannot travel through a vacuum. They are **longitudinal** waves, so vibrate in the direction they travel in, unlike electromagnetic waves which are **transverse** (i.e. vibrate perpendicularly to the direction of travel).

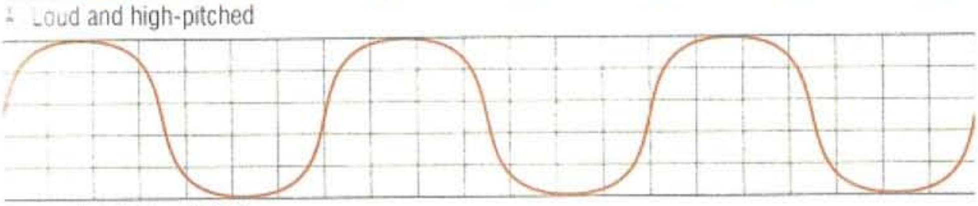
Sound can be reflected in an **echo**. This can be heard in large rooms with bare, smooth walls. If the walls were covered in fabric, the sound would be absorbed, so no echo heard. If the walls are not smooth, and are uneven, there won't be an echo because the sound is broken up.

Sound **refraction** depends on the temperatures of the air. At nighttime, sound refracts back down to the ground so you can hear it a long distance from the sound source. Whereas during the daytime, sound refracts upwards not downwards because the air nearer the ground is warmer.

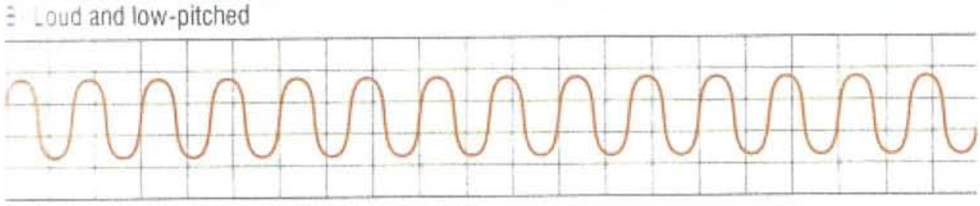
Musical sounds are gentle to listen to because they are rhythmic and the wave pattern repeatedly repeats itself. **Noise** consists of sound waves with varying frequency and no set pattern.



A Loud and high-pitched



B Loud and low-pitched



C Quiet and high-pitched (higher pitch than A)

Increasing **loudness** of a sound increases the **amplitude** (biggest disturbance) of the waves, i.e. makes them taller.

Increasing the **frequency** of a sound (the number of waves per second) increases **pitch**, i.e. makes more waves appear closer together.

Ultrasound

Humans can hear frequencies between 20Hz and 20,000Hz – any sound waves with frequencies above the human ear are said to be **ultrasonic waves**. We have many uses for ultrasound.

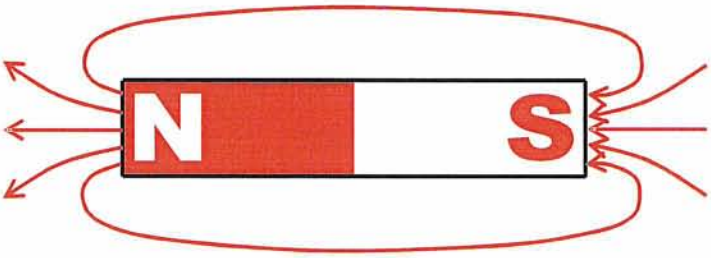
One example of its use is for ultrasound scanning, used for scanning body organs or babies in the womb. A probe sends out ultrasonic pulses and detects pulses that are deflected back and when they are deflected back. As the probe is moved around, for example, the mother, an entire virtual image is built up.

Another use is for finding **flaws** in metals. A flaw is an internal crack. The ultrasonic transmitter sends out ultrasonic pulses along the metal, which are deflected back along the boundary the flaw lies on.

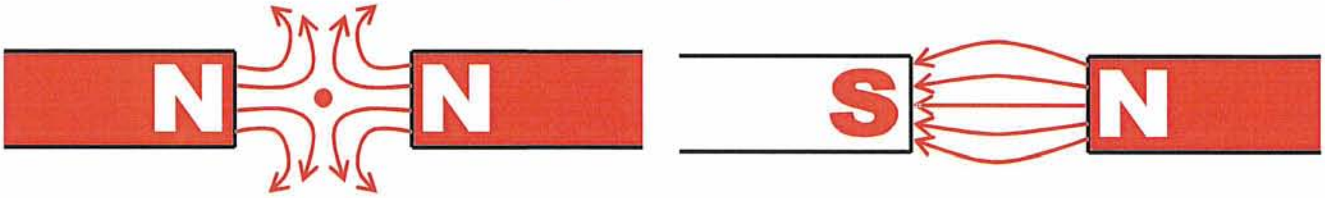
4 Electromagnetism

Basic Magnetism

A **magnetic field** is any region in which a magnetic force is exerted. **Magnetic field lines** always go from **north** to **south**.

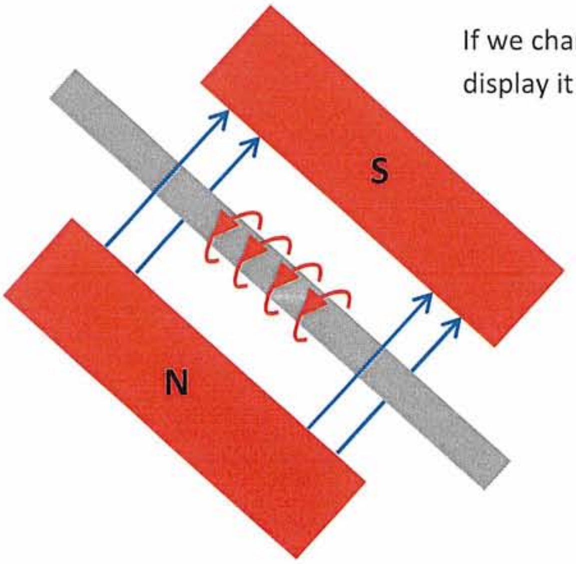


Opposite poles **attract** and like poles **repel** each other.

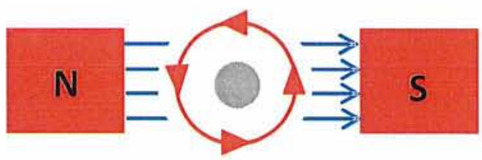


The point at which there is no magnetic force is the **neutral point** (●).

The diagram below shows a wire in between two magnets.

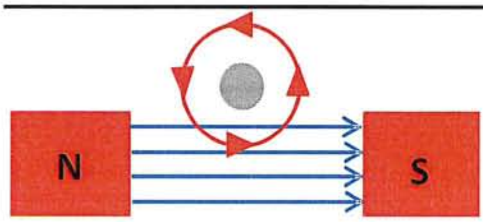


If we change the perspective of the diagram, we can display it like below:



The diagram above shows that the magnetic field lines go straight from north to south, but only some of the field of the wire agrees with the magnetic field lines (i.e. only part of the wire's field is going in the same direction as the poles' field lines).

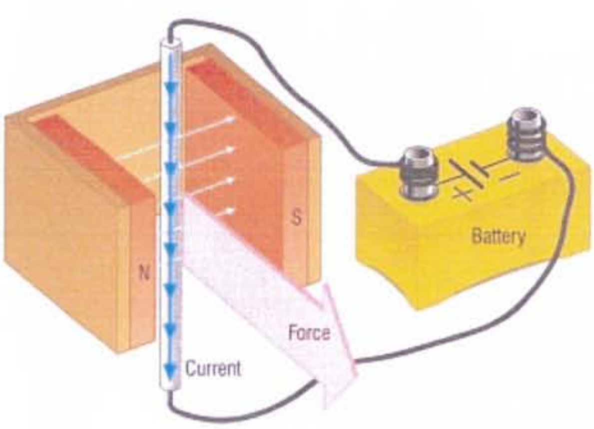
Because of this disagreement in field lines, the magnetic force pushes the wire upwards to knock out all of the forces travelling in the opposite direction to the magnetic field lines:



This effect is known as the **catapult effect.**

The Motor Effect

When a current is passed along a wire in a magnetic field, a force may be exerted on the wire. This is the **motor effect.**

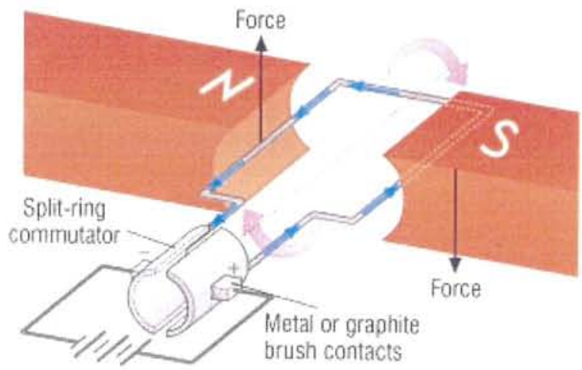


There is always a force acting on the wire unless the wire is parallel to the magnetic fields. The force can be increased by increasing the current or using a stronger magnet.

The force depends on the angle between the wire and the **magnetic field lines.** The force is biggest when the wire is perpendicular to the field lines, nil when parallel.

An **electric motor** is designed to use the motor effect. We can change its speed by alternating the current, and reverse its speed by reversing the current.

The coil in the motor shown (the **armature coil**) is forced to rotate. The coil is connected to a battery via two metal or graphite **brushes.** These brushes are fixed onto a **split-ring commutator** which is connected to the rectangular coil.



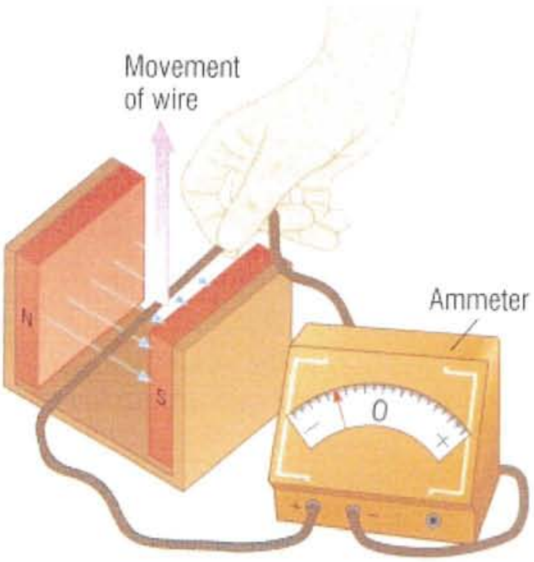
When a current is passed through the coil, it spins because:

- a force acts on either side due to the motor effect
- the force on one side is in the opposite direction to the other side

The split ring commutator reverses the current every half-turn of the coil – and because the sides swap over every half turn, the coil is pushed continually in the same direction over and over.

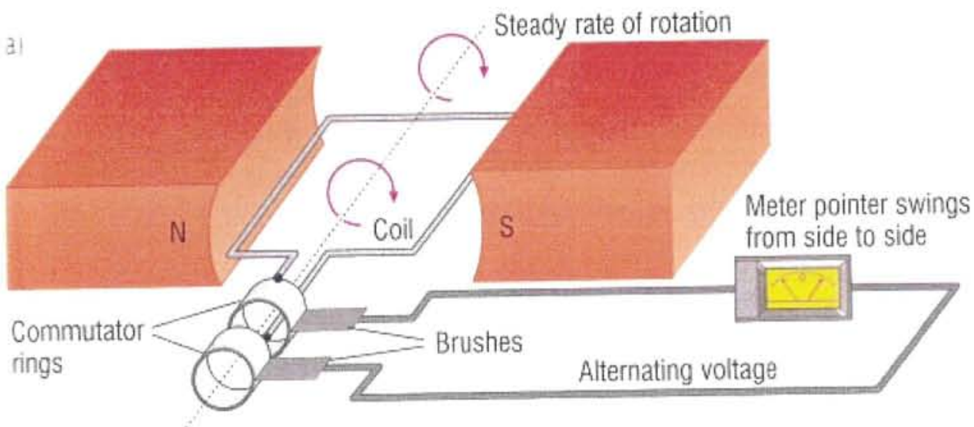
Electromagnetic Induction

Hospitals have emergency electricity **generators** in case the mains fails. A generator contains coils of wire which spin in a magnetic field. A **potential difference** (or **voltage**) is created (or **induced**) in the wire when it cuts across field lines. If the wire is part of a complete circuit, the induced potential difference makes an electric current pass around the circuit.

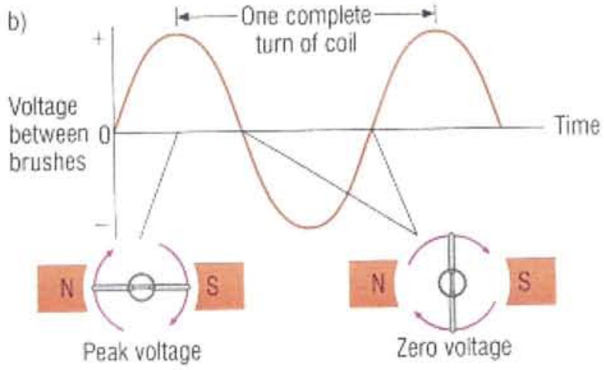


If you connect some insulated wire to an **ammeter** and move it between two poles of a **U-shaped magnet**, you notice the ammeter pointer deflects as a current is generated when the wire cuts a magnetic field line. This effect is known as the **dynamo effect**. Making the wire into a coil would increase the current.

A simple **a.c. generator** is made using a rectangular coil forced to spin in a magnetic field.



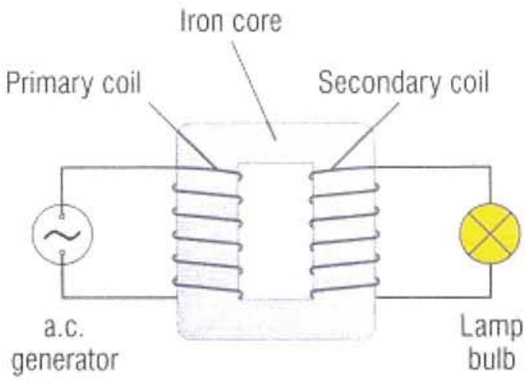
The coil is connected to an ammeter via the metal brushes attached to the commutator rings. When the coil turns steadily in one direction, the meter pointer deflects one way first, then the opposite way, and then back again. This carries on as long as the coil continues turning. The current through the meter is **alternating current** (a.c.).



The faster the coil rotates, the larger the peak value of the alternating current; and the greater the frequency (i.e. number of cycles per second) of the alternating current.

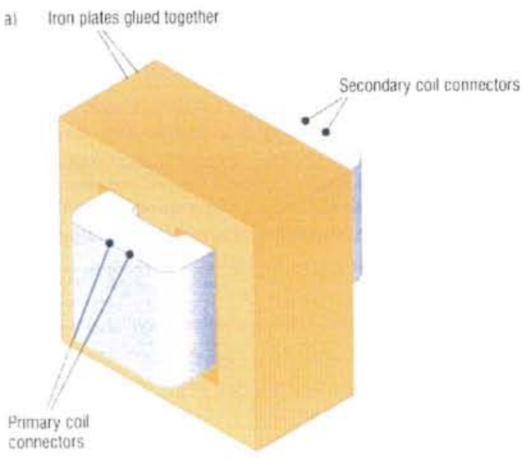
Transformers

Transformers



Electricity reaches our homes from a power station via a network of cables called the **National Grid**. A **transformer** is used at each stage to change the alternating voltage. A transformer consists of two coils of insulated wire, both wound round the same **iron core**. When an alternating current passes through the **primary coil**, an alternating potential difference is induced in the **secondary coil**. This happens because the alternating current in the primary coil induces an alternating magnetic field, and those alternating magnetic field lines pass through the secondary coil and induce an alternating voltage. The induced alternating potential difference in the secondary circuit causes a current and so the bulb lights up. Therefore, electrical energy has been passed from the primary coil to the secondary coil even though they are not connected as one circuit.

Transformers will only work with an alternating current, because a direct current does not induce alternating magnetic fields and so an alternating secondary voltage cannot be produced.

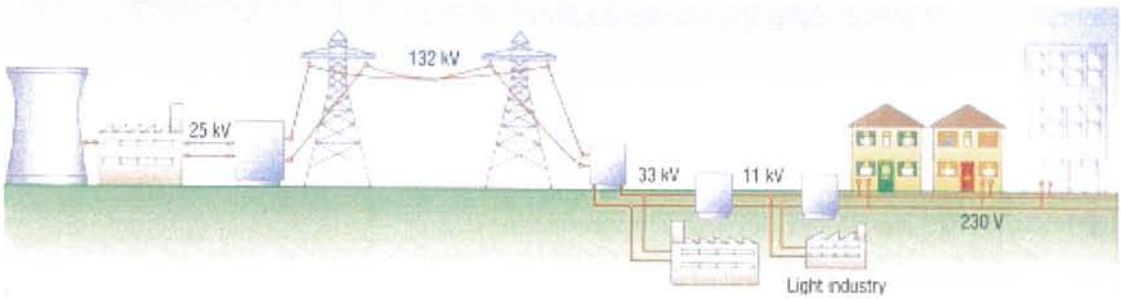


The primary and secondary coils are both wound round the same part of the core. The core is layered (laminated) to cut out induced current in the iron layers. If it was not laminated, the efficiency of the transformer would be greatly reduced.

The National Grid

Electricity is supplied to our homes via the **National Grid**. The higher the potential difference, the greater the efficiency of transferring the electrical power through the grid. This is why we use:

- **step-up transformers** to take the p.d. from a power station up to the Grid p.d.
- **step-down transformers** to step the p.d. down to mains voltage



The secondary p.d. of a transformer depends on the primary p.d. and the number of turns on both coils:

$$\frac{\text{p.d. of primary } (V_P)}{\text{p.d. of secondary } (V_S)} = \frac{\text{number of turns on primary } (N_P)}{\text{number of turns on secondary } (N_S)}$$

For a step-*up* transformer, NS is greater than NP and VS is more than VP
For a step-*down* transformer, NS and VP are less than NP and VP

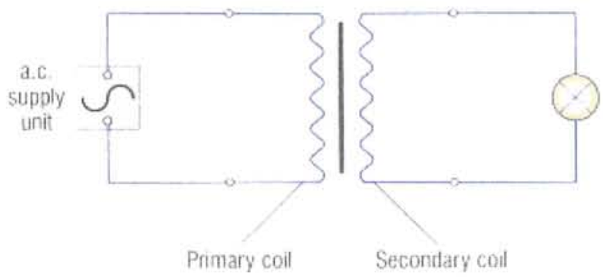
Transformers are almost 100% efficient:

power supplied to transformer = primary current x primary p.d.
power delivered by transformer = secondary current x secondary p.d.

Therefore, with 100% efficiency:

primary current x primary p.d. = secondary current x secondary p.d.

$$I_P V_P = I_S V_S$$



E End of Unit Questions

P3-1 : Moments

1 What is the moment of a force?
2 Define the terms: load, effort and pivot
3 How do you work out a moment?
4 What is meant by the centre of mass?
5 What is another name for the centre of mass?
6 When is an object in equilibrium?
7 Explain non-equilibrium
8 Where is the centre of mass for a rectangle?
9 Explain the Principle of Moments
10 Explain how a tractor is adopted to stay upright
11 What makes an object topple?
12 What is circular motion?
13 Explain the difference between circular motion and centripetal force?
14 Name Newton's laws of gravity
15 Define gravitational field strength
16 How does a planet stay in orbit
17 Name and explain the function of two satellite types

P3-2 : Space

1 What was the Big Bang?
2 What is background radiation and what does it show?
3 Describe in detail the life of a star
4 Explain the term protostar
5 What decides if a star becomes a supernova or black dwarf?
6 How did the lighter-massed elements form?
7 How did the heavier elements form?
8 What does our planet tell us in terms of elements?

P3-3 : Light & Sound

1 What's the difference between a concave and convex mirror?
2 Explain the difference between reflection and refraction
3 What is the angle of incidence/reflection/refraction?

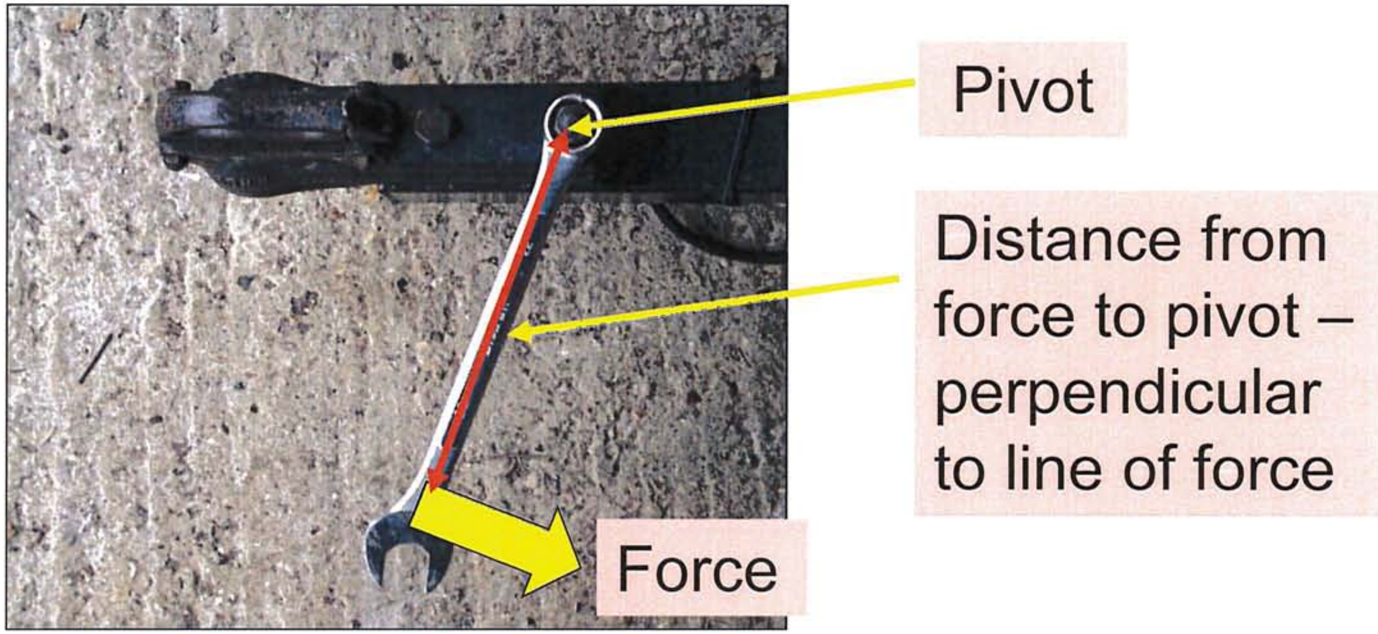
4 What is the normal?
5 Describe a virtual and real image formation
6 What is meant by the principal axis?
7 What is meant by focal length?
8 Explain image formation using converging and diverging lenses
9 How does a magnifying glass work?
10 What creates sound?
11 Why can't sound waves travel through a vacuum?
12 What is meant by sound echo?
13 What does an increase in frequency tell us about a sound?
14 Explain the difference between noise and musical notes
15 Give and explain one use of ultrasound in society

P3-4 : Electromagnetism

1 What is the motor effect?
2 How can the force be increased?
3 How does an electric motor work?
4 What is meant by electromagnetic induction?
5 Explain the dynamo effect
6 Describe an a.c. generator and how it works
7 What are transformers used for?
8 What do we call the network of cables supplying electricity from power stations to our homes?
9 Explain when step-up and step-down transformers are used
10 Why are iron layers laminated in transformers?
11 Why is efficiency of transformers increased as the grid potential difference increases?

How do forces have a turning effect?

- The **turning effect** of a force is called the **moment**.



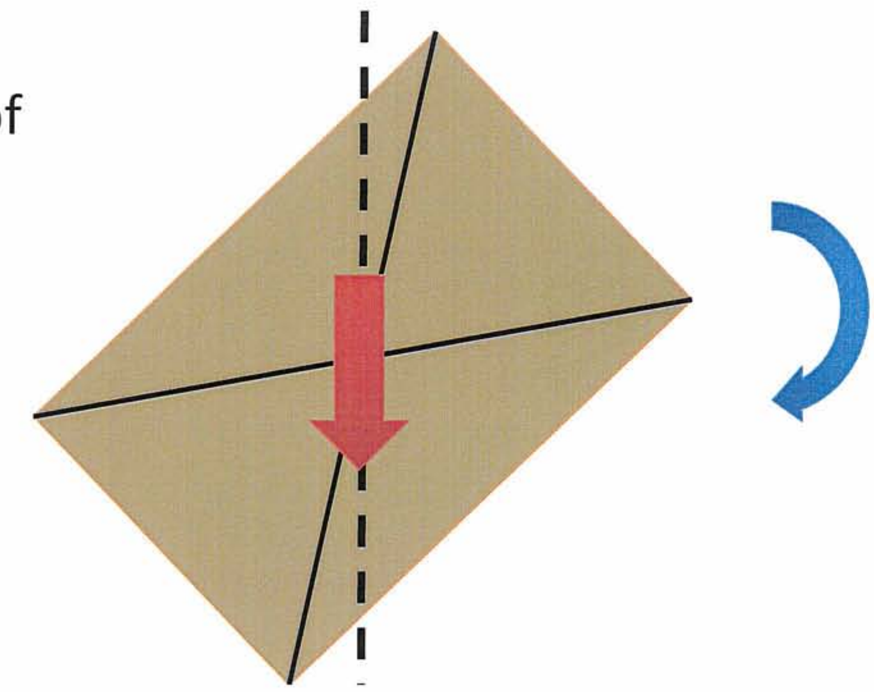
- The size of the moment is given by the equation:

moment (newton metre, Nm)	=	force (newton, N)	×	perpendicular distance from the line of action of the force to the axis of rotation (metre, m)

How do forces have a turning effect?

- The **centre of mass** of a body is the point at which the mass of the body may be thought to be **concentrated**.
- If suspended, a body will come to rest with its centre of mass directly below the point of suspension.
- The centre of mass of a **symmetrical** body is along the **axis** of symmetry.
- If a body is not turning, the total **clockwise moment** must be exactly **balanced** by the total **anticlockwise moment**.

- If the **line of action** of the weight of a body lies **outside** the base of the body there will be a resultant moment and the body will tend to **topple**.

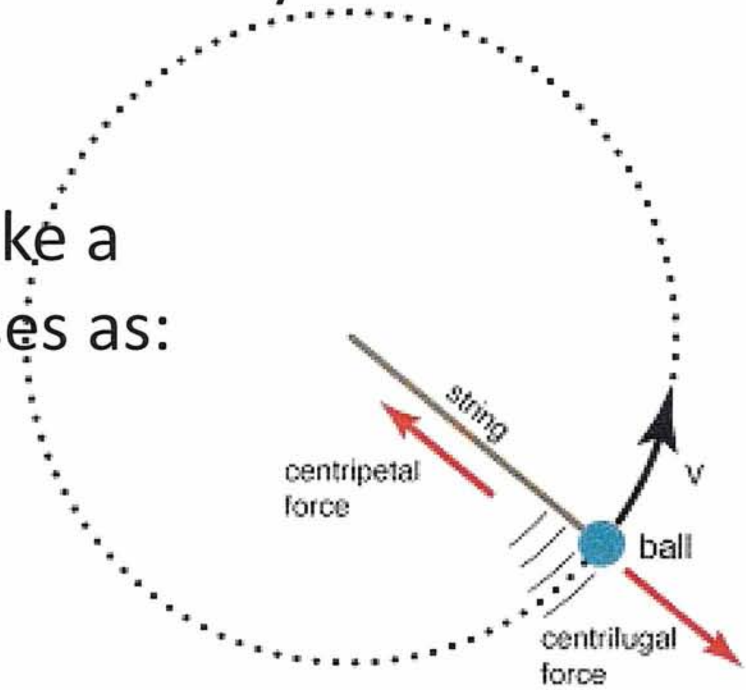


What keeps bodies moving in a circle?

- When a body moves in a circle it continuously **accelerates** towards the centre of the circle. This **acceleration** changes the **direction** of motion of the body, **not** its **speed**.
- The resultant force causing this acceleration is called the **centripetal force**.
- The direction of the centripetal force is always towards the **centre** of the circle.

- The centripetal force needed to make a body perform circular motion increases as:

– the **mass** of the body **increases**;
– the **speed** of the body **increases**;
– the **radius** of the circle **decreases**.

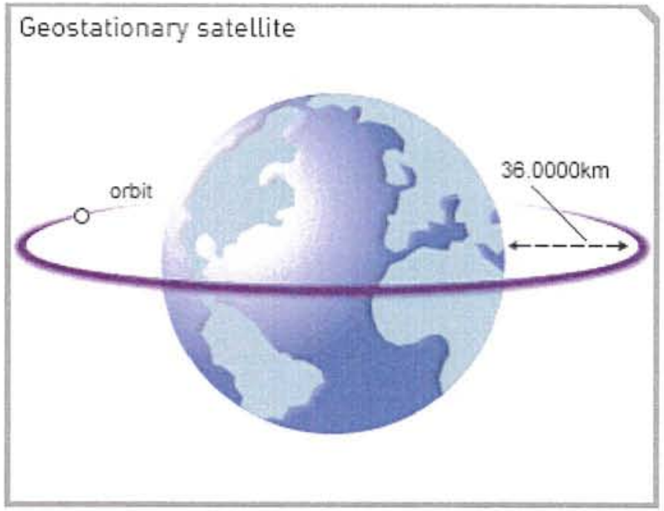


What provides the centripetal force for planets and satellites?

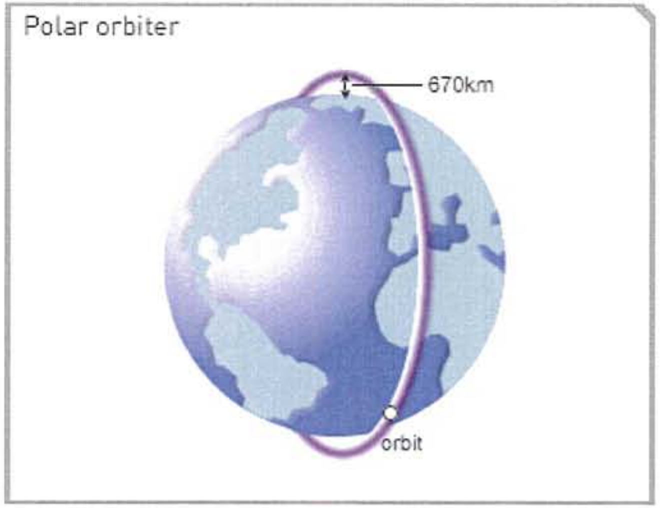
- The **centripetal force** that allows planets and satellites to maintain their circular orbits is called **gravity.**
- The bigger the **masses** of the bodies the **bigger** the force of gravity between them.
- As the **distance** between two bodies **increases** the force of gravity between them **decreases**.
- The further away an orbiting body is the **longer** it takes to make a complete orbit.
- To stay in orbit at a **particular distance**, planets and satellites must move at a **particular speed** around larger bodies.

What provides the centripetal force for planets and satellites?

- **Communications** satellites are usually put into a **geostationary orbit** above the equator.

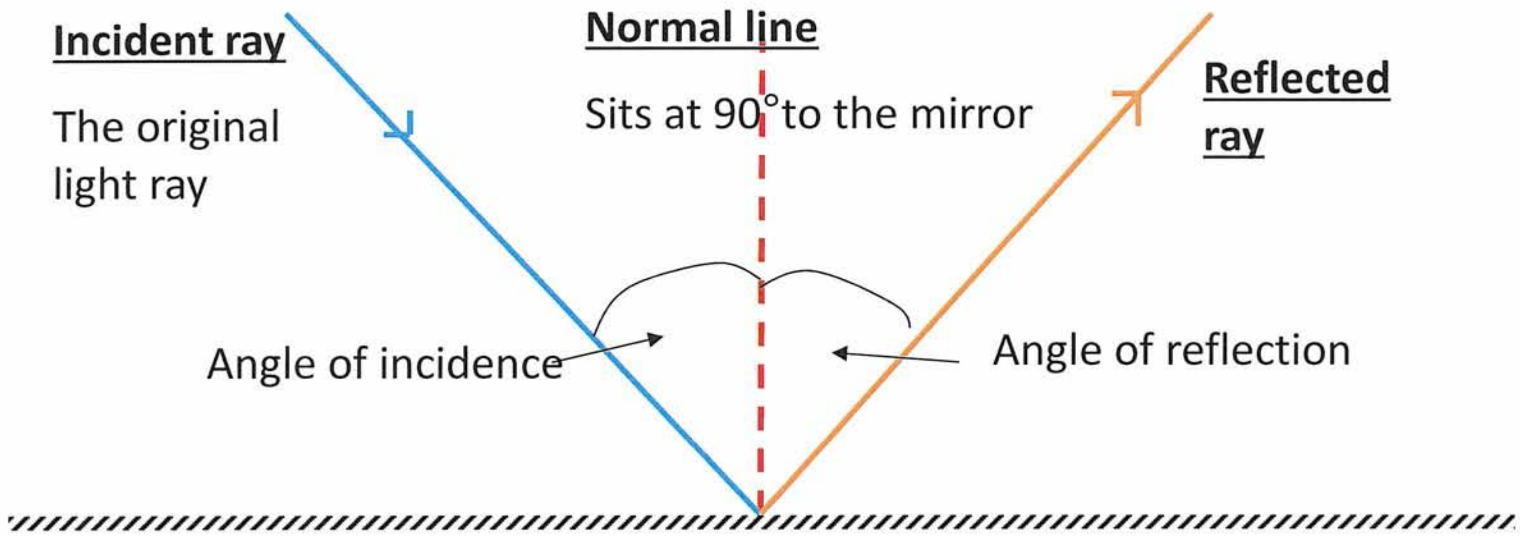


- **Monitoring** satellites are usually put into a **low polar orbit**.



What do mirrors and lenses do to light?

- The **normal** is a construction-line **perpendicular** to the reflecting/refracting surface at the point of **incidence**.
- The **angle of incidence** is equal to the **angle of reflection**.



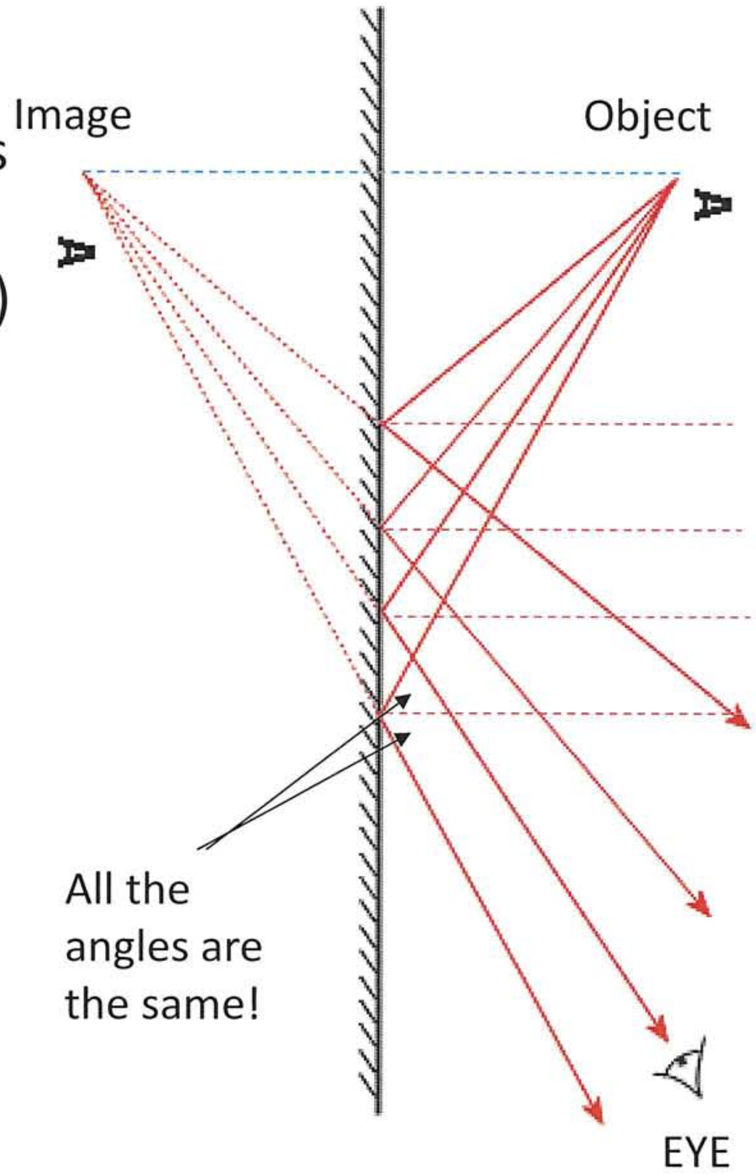
- You calculate the **magnification** produced by a lens or mirror using the formula:

$$\text{magnification} = \frac{\text{image height}}{\text{object height}}$$

What is the nature of images produced by mirrors?

- The image produced by a **plane** mirror is always:

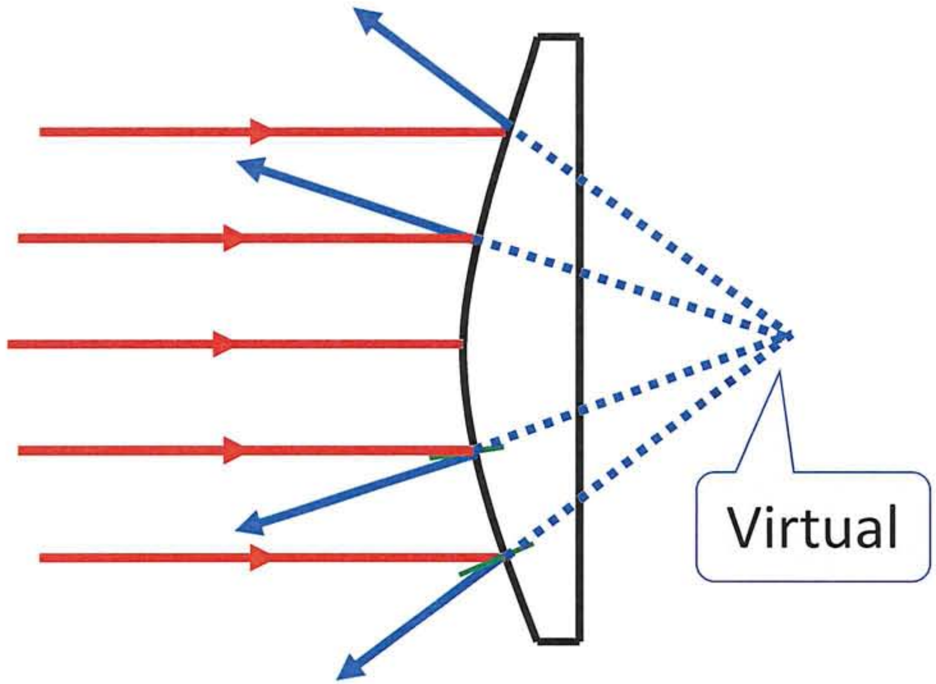
- **Virtual** (appears to be behind the mirror)
- **Upright**
- The same **size** and **distance** from the mirror as the object is.



What is the nature of images produced by mirrors?

- The **normal** to the surface of **convex** and **concave** mirrors changes at each spot of the mirror.
- The nature of the image produced by a convex mirror is always:

- **Virtual** (appears behind the mirror)
- **Upright**
- **Smaller**



What is the nature of images produced by mirrors?

- **Concave mirrors** focus light inward to one focal point.
- Concave mirrors show **different** image types depending on the **distance** between the object and the mirror.

Inverted, **smaller**, **real** (flipped by a mirror before we see it)

No image – focusing or spreading light

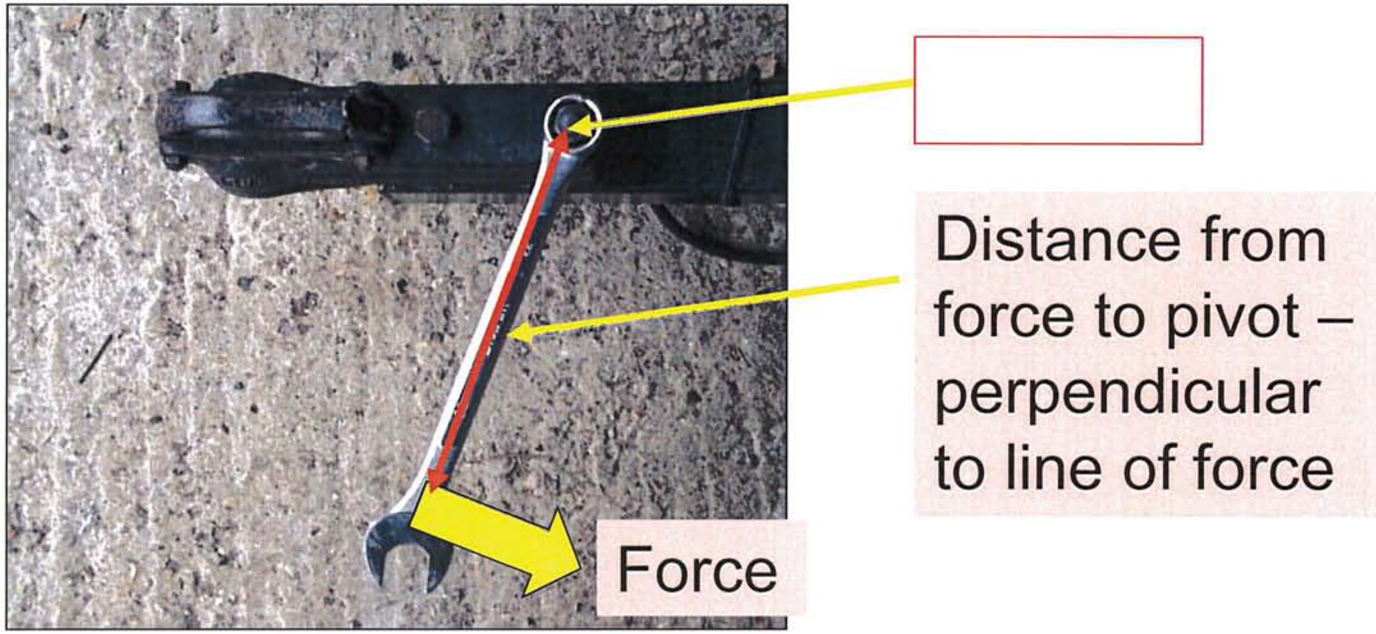
Upright, larger, virtual

10 minutes

Who can make the best plasticine fish?

How do forces have a turning effect?

- The **turning effect** of a force is called the ______



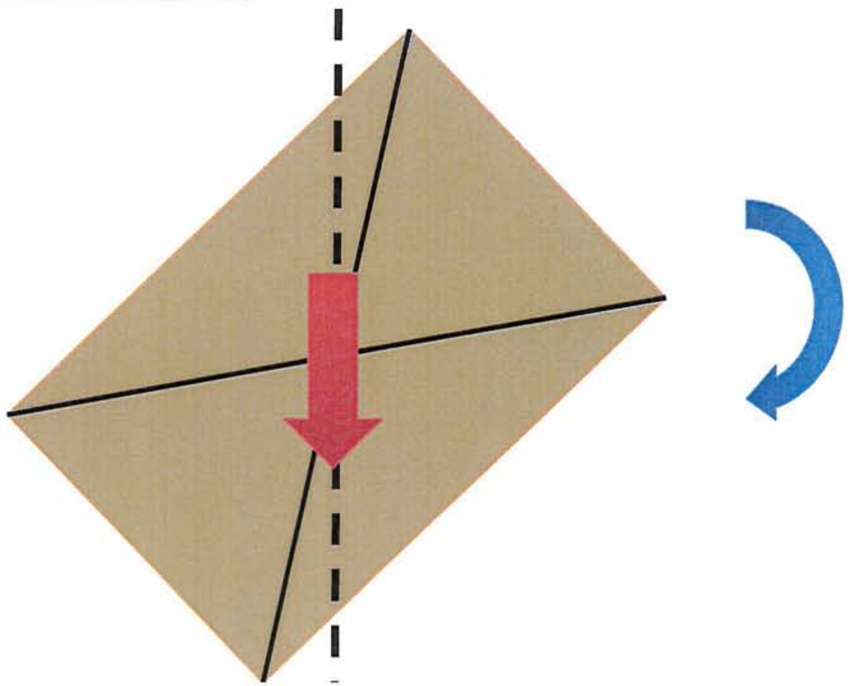
- The size of the moment is given by the equation:

moment	=	force	×	______
(newton metre, Nm)		(newton, N)		

How do forces have a turning effect?

- The ______ of a body is the point at which the mass of the body may be thought to be **concentrated**.
- If suspended, a body will come to rest with its centre of mass directly ______ the point of suspension.
- The centre of mass of a **symmetrical** body is along the ______
- If a body is not turning, the total ______ must be exactly **balanced** by the total ______

- If the ______ of the weight of a body lies **outside** the base of the body there will be a resultant moment and the body will tend to ______



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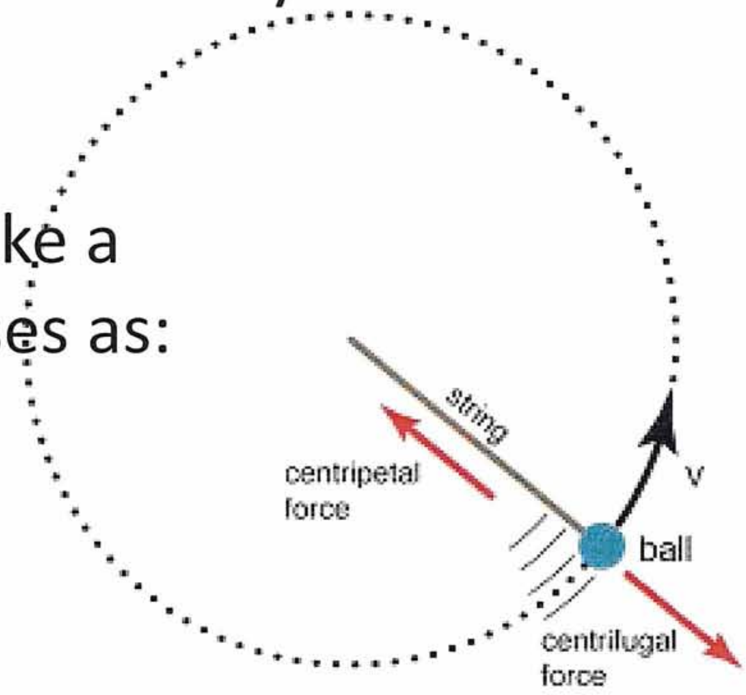
– the **mass** of the body ______
– the **speed** of the body ______
– the **radius** of the circle ______



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- The further away an orbiting body is the ______ it takes to make a complete orbit.
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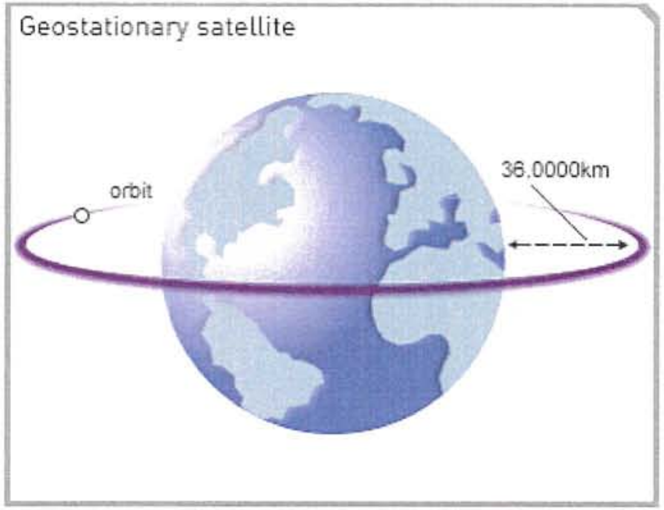
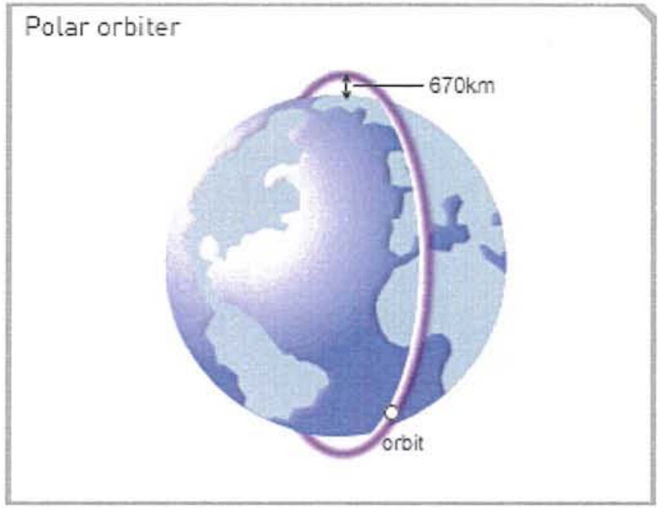
What provides the centripetal force for planets and satellites?

- ______ satellites are usually put into a **geostationary orbit** above the equator.

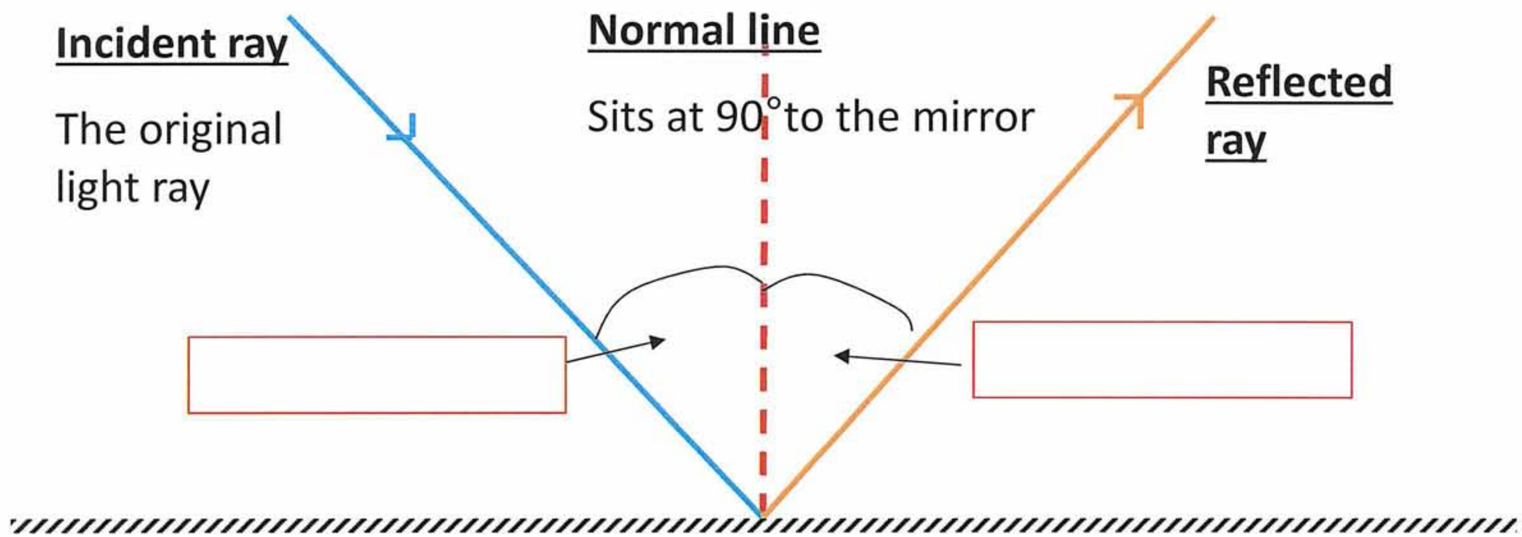


- **Monitoring** satellites are usually put into a ______ ______



What do mirrors and lenses do to light?

- The ______ is a construction-line **perpendicular** to the reflecting/refracting surface at th______**ncidence**.
- The **angle of** ______ is equal to the **angle of** ______



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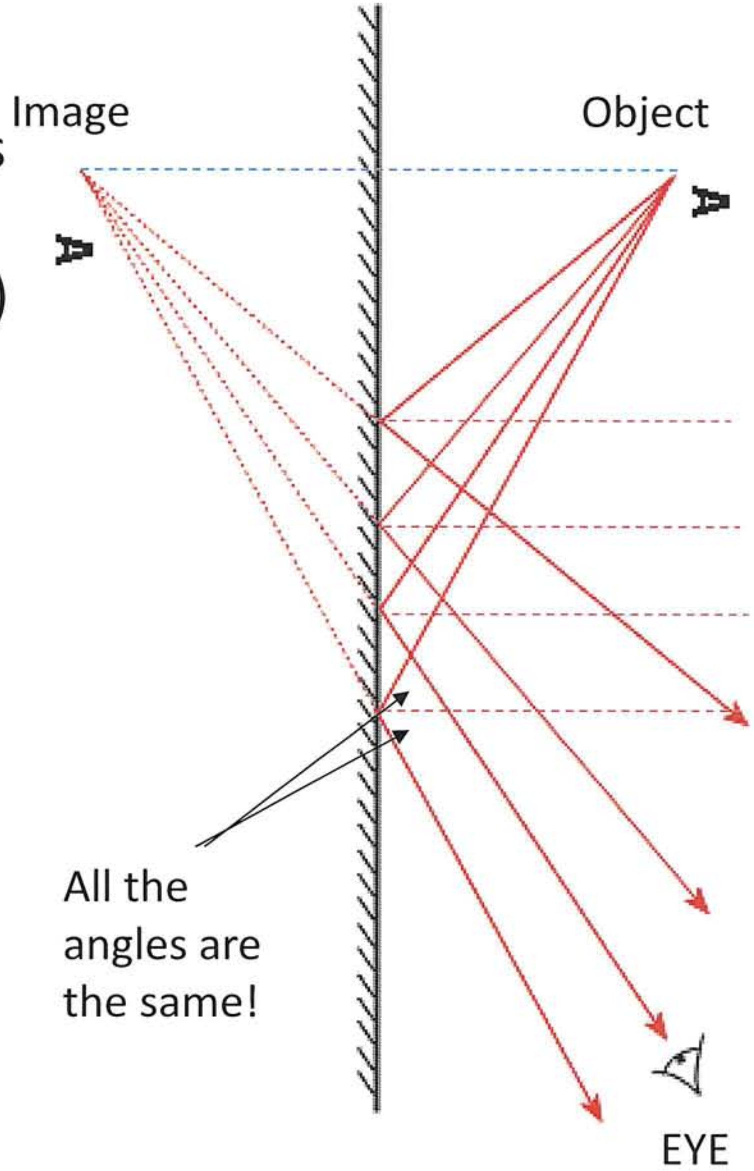
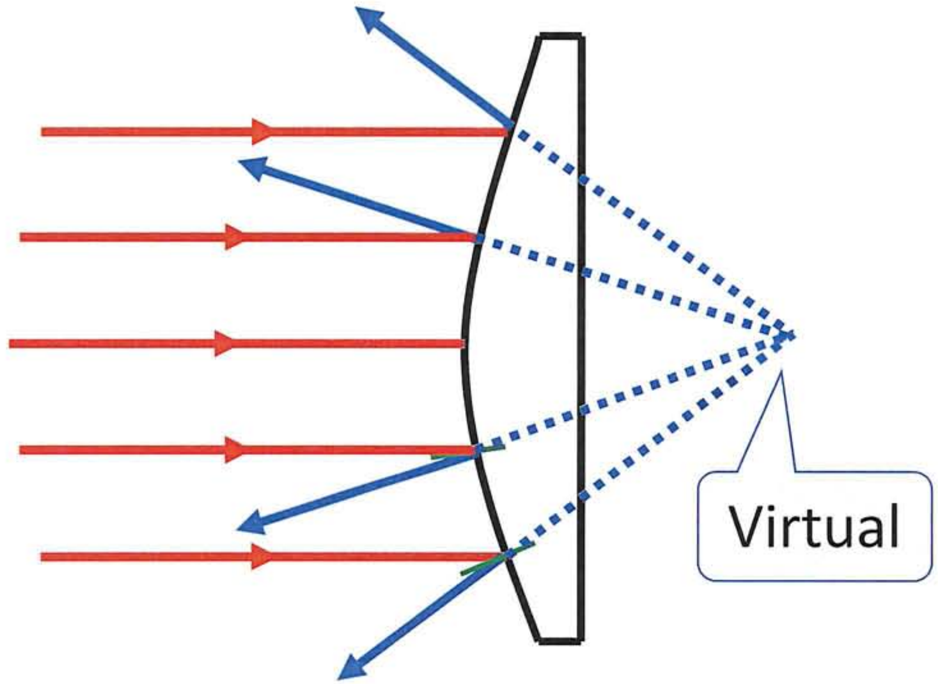


What is the nature of images produced by mirrors?

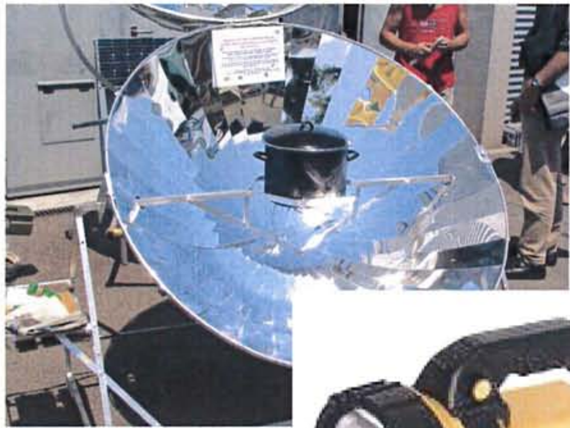
- The **normal** to the surface of [ ] and [ ] mirrors changes at each spot of the mirror.
- The nature of the image produced by a convex mirror is always:

- **Virtual** (appears behind the mirror)
- **Upright**
- [ ]



What is the nature of images produced by mirrors?

- ______ **mirrors** focus light inward to one focal point.
- They show **different** image types depending on the ______ between the object and the mirror.



Inverted, **smaller**, ______ (flipped by a mirror before we see it)

No image – focusing or spreading light

Upright, ______ **virtual**

10 minutes

Who can make the best plasticine dinosaur?

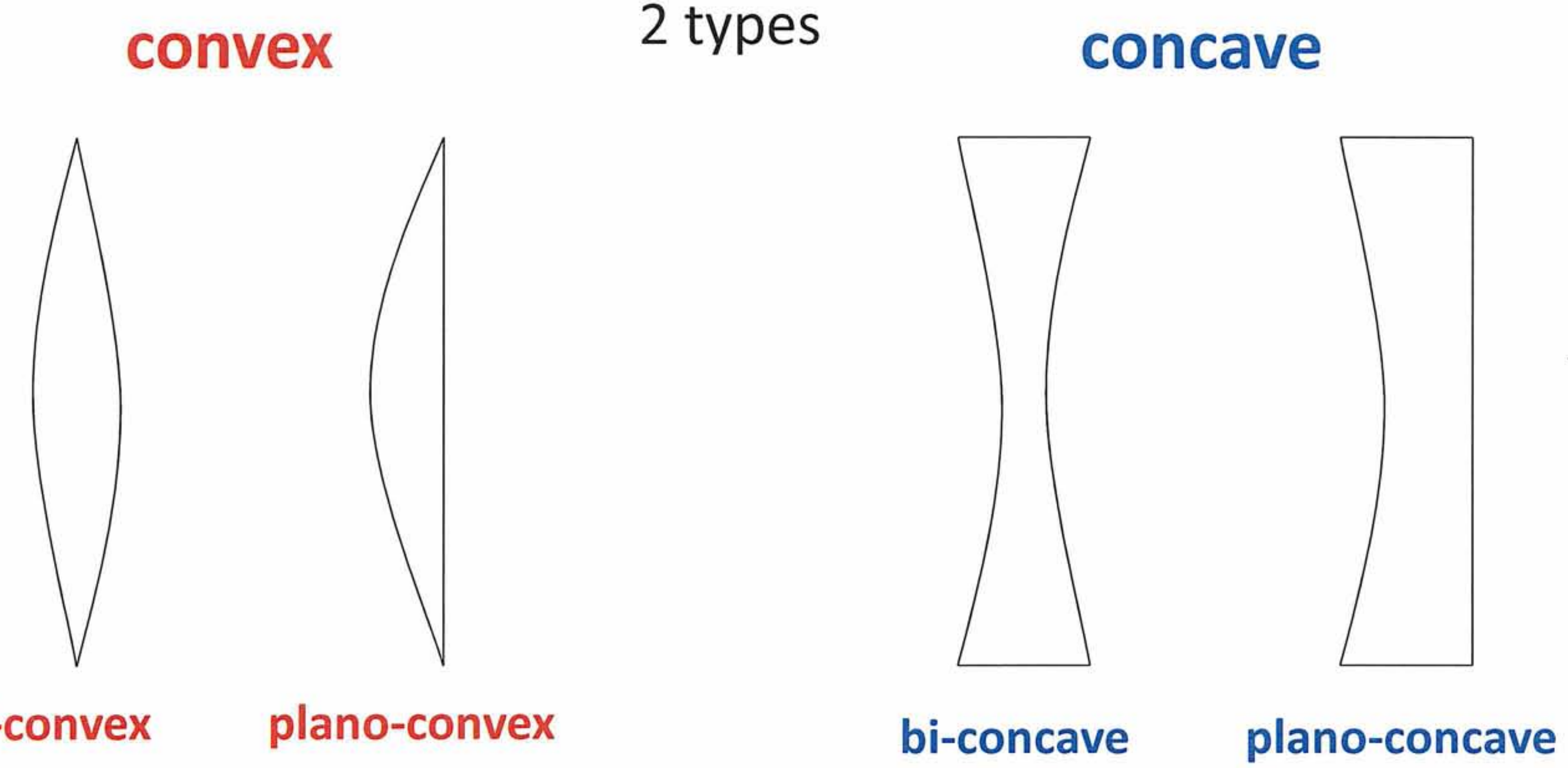
Exam Questions

- Answer the exam questions on
  - Forces and moments
  - Circular motion
  - Mirrors

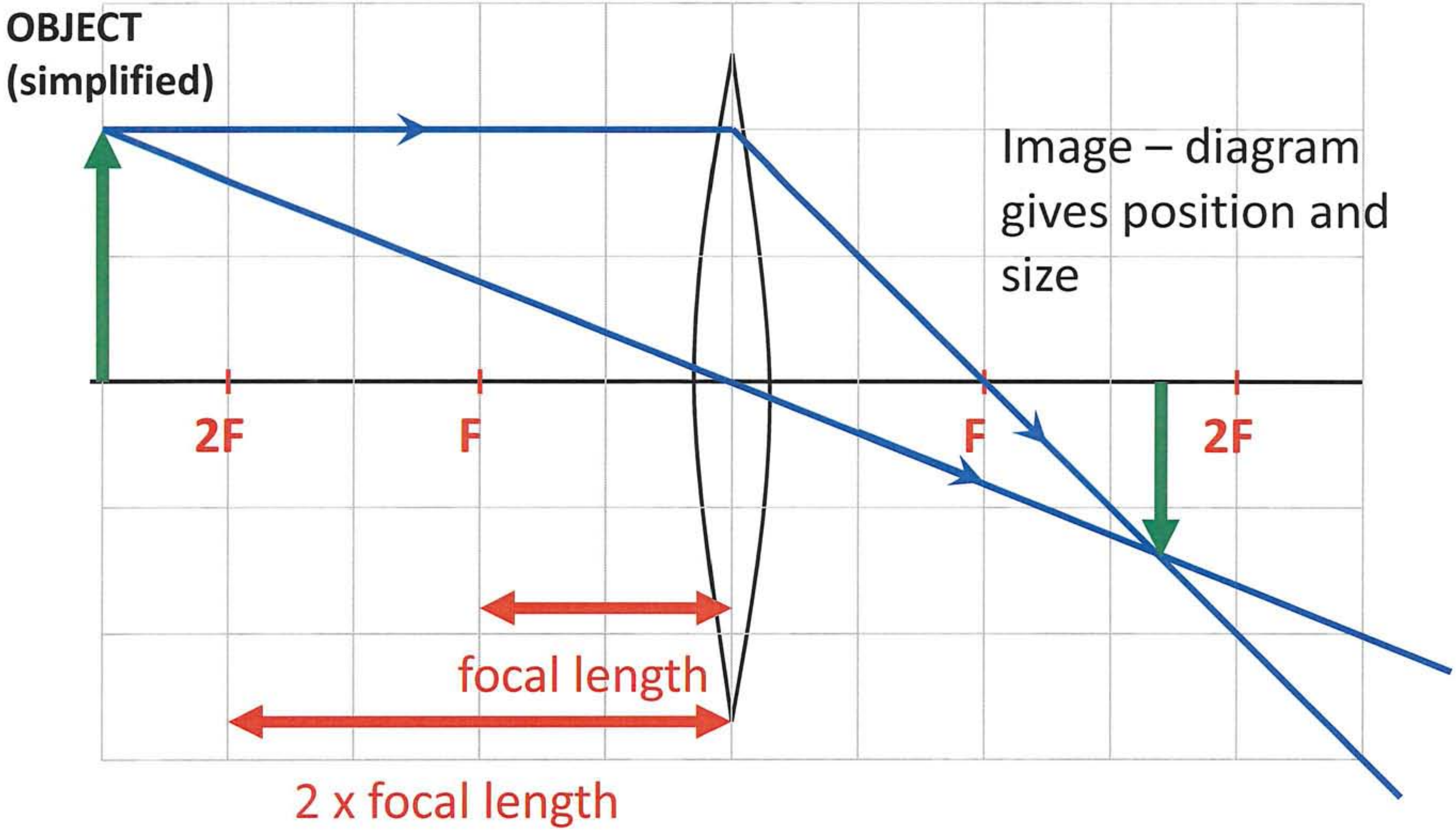
What is the nature of images produced by lenses?

Lenses REFRACT light and are usually used to form IMAGES

2 types



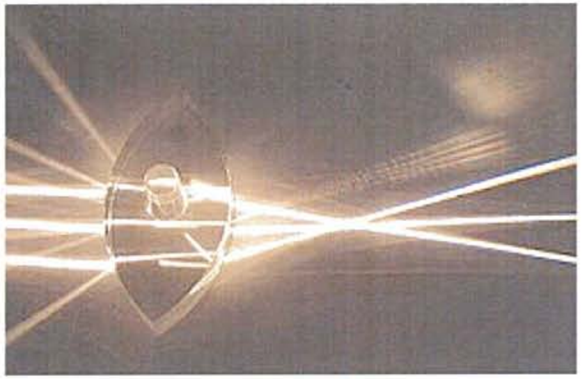
RAY DIAGRAMS:RULES



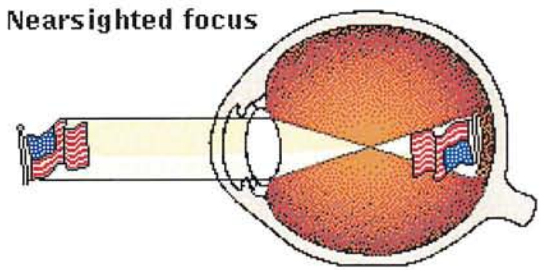
1. A ray parallel to the axis is refracted through the focus
2. A ray to the centre of the lens passes through undeflected
3. Top of image forms where rays cross.

What is the nature of images produced by lenses?

- A **converging lens** creates a different image depending on the **distance** between the object and the lens



- Converging lenses can be used in **a camera** to produce an image of an object on a **detecting device** (eg film) and in your **eye** to focus light onto your **retina**.

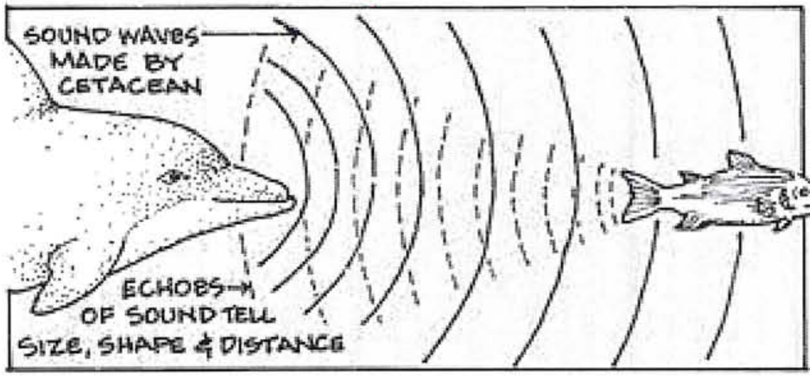


What is sound?

- Sound is caused by **mechanical vibrations** and travels as a **wave**.
- Sounds in the range **20-20 000 Hz** can be detected by the human ear.
- Sound cannot travel through a **vacuum**.
- The **pitch** of a note **increases** as the **frequency increases**.
- The **loudness** of a note **increases** as the **amplitude** of the wave **increases**.
- The **quality** of a note depends upon the **waveform**.
- Sound waves can be **reflected** and **refracted**.

What is ultrasound?

- Ultrasound waves have a frequency **higher** than the upper limit of **hearing for humans** (**20kHz**)
- Ultrasound waves are partially **reflected** when they meet a **boundary** between two different surfaces.
- The **time taken** for the reflections to reach a detector is a measure of how **far away** the boundary is.



Distance = Speed x Time

- Ultrasound waves can be used in **industry** for **cleaning** and quality control.
- Ultrasound waves can be used in **medicine** for **pre-natal scanning**.

How can electricity make things move?

• When a **conductor** (wire) carrying an **electric current** is placed in a **magnetic field**, it experiences a force. This is called the **motor effect**.

• The size of the force can be **increased** by:

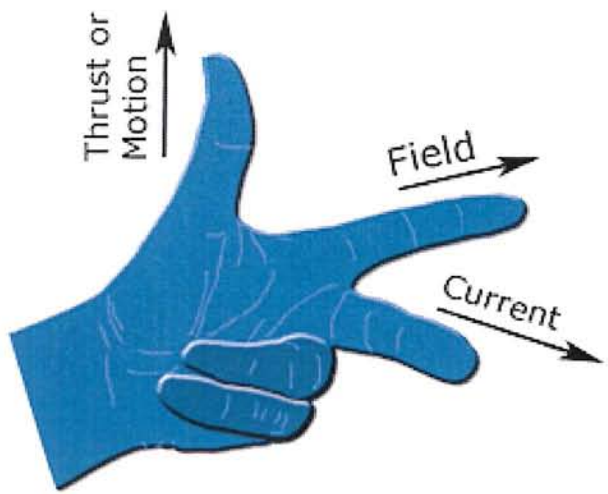
– increasing the **strength** of the **magnetic field**

– increasing the size of the **current**.

• The conductor will not experience a force if it is **parallel** to the magnetic field.

• The direction of the force is **reversed** if either the direction of the **current** or the direction of the **magnetic field** is reversed.

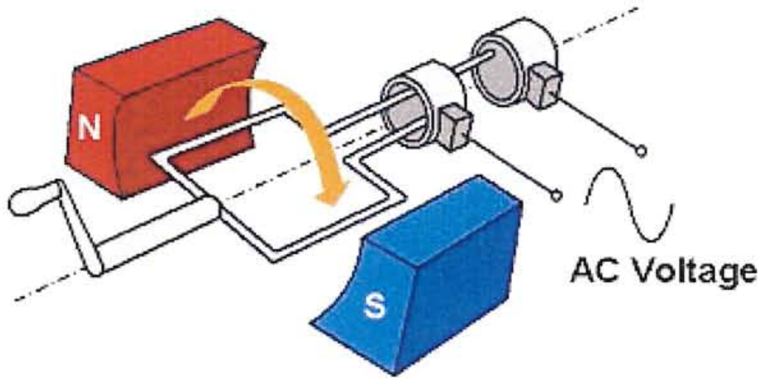
• We can use Fleming's **LEFT hand** rule to determine the **direction** of **movement**, the **current** or **magnetic field**

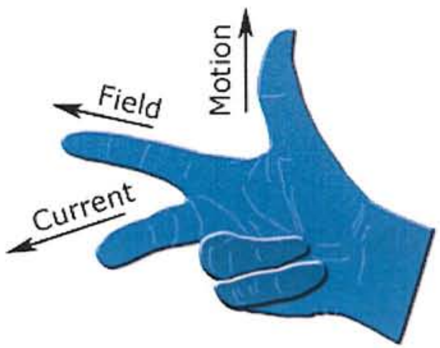


How do generators work?

- If an **electrical wire** 'cuts' through **magnetic field lines**, an electrical **potential difference** is induced across the ends of the conductor.
- If the conductor is part of a complete circuit, a **current** is **induced** in the wire.
- If the **direction** of motion, or the polarity of the magnet, is **reversed**, the direction of the induced current is **reversed**.
- The generator effect also occurs if the **magnetic field** is **stationary** and the **coil** is **moved**.
- The size of the induced potential difference increases when:

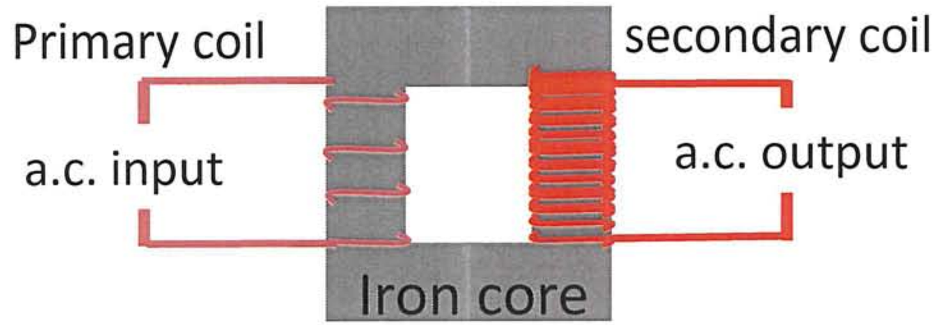
– the **speed** of the movement **increases**
– the **strength** of the magnetic field **increases**
– the **amount** of **wire** in the coil **increases**





- Fleming's **RIGHT hand** rule applies to generators

How do transformers work?



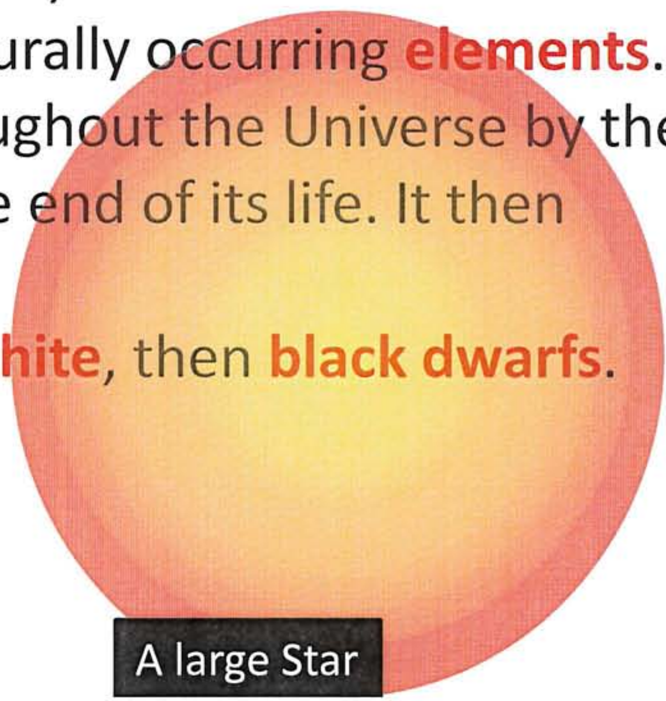
$$\frac{\text{Voltage across the primary coil}}{\text{Voltage across the secondary coil}} = \frac{\text{Number of loops on the primary coil}}{\text{Number of loops on the secondary coil}}$$

- An **alternating current** in the **primary coil** produces a **changing magnetic field** in the **iron core** and therefore in the **secondary coil**.
- This induces an **alternating potential difference** across the ends of the **secondary coil**.
- In a **step-up** transformer the potential difference across the secondary coil is **greater**
- In a **step-down** transformer the potential difference across the secondary coil is **less**
- Step-up and step-down transformers are used in the **National Grid** to transfer electricity at a higher voltage but **lower current** reducing wasted **heat** energy.

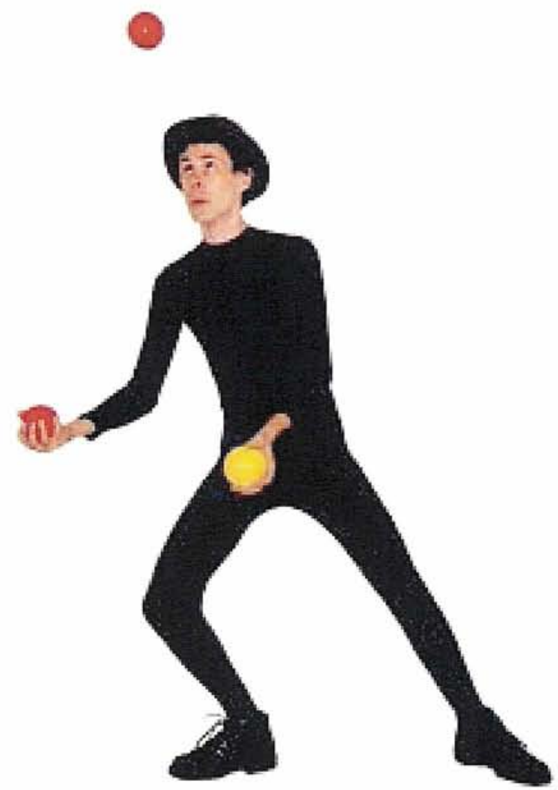
What happens during the life of a star?

- The Universe is made up of billions of **galaxies**. Our Sun is one of billions of **stars** in the **Milky Way** galaxy.
- Stars **form** when enough dust and gas from space is pulled together by **gravity**– a **nebula** forms.
- **Friction** between particles causes heat **radiation** which is balanced by **gravity** to make a star **stable** (like our Sun).
- **Fusion** processes in stars produce all naturally occurring **elements**.
- These elements may be distributed throughout the Universe by the explosion of a **large** star (**supernova**) at the end of its life. It then cools to form a **neutron** star or **black hole**.
- **Smaller** stars expand and cool forming **white**, then **black dwarfs**.


Star like our Sun


A large Star

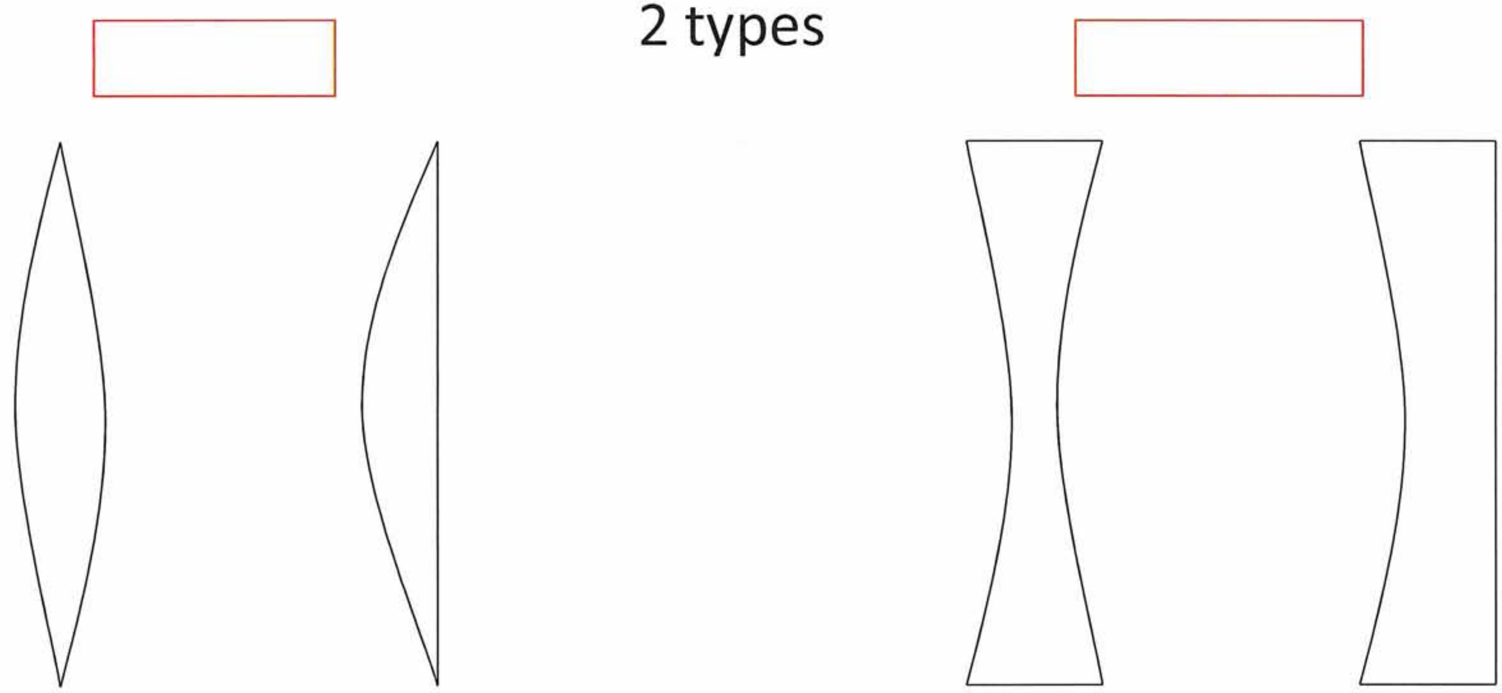
How long can you juggle for without dropping a ball?



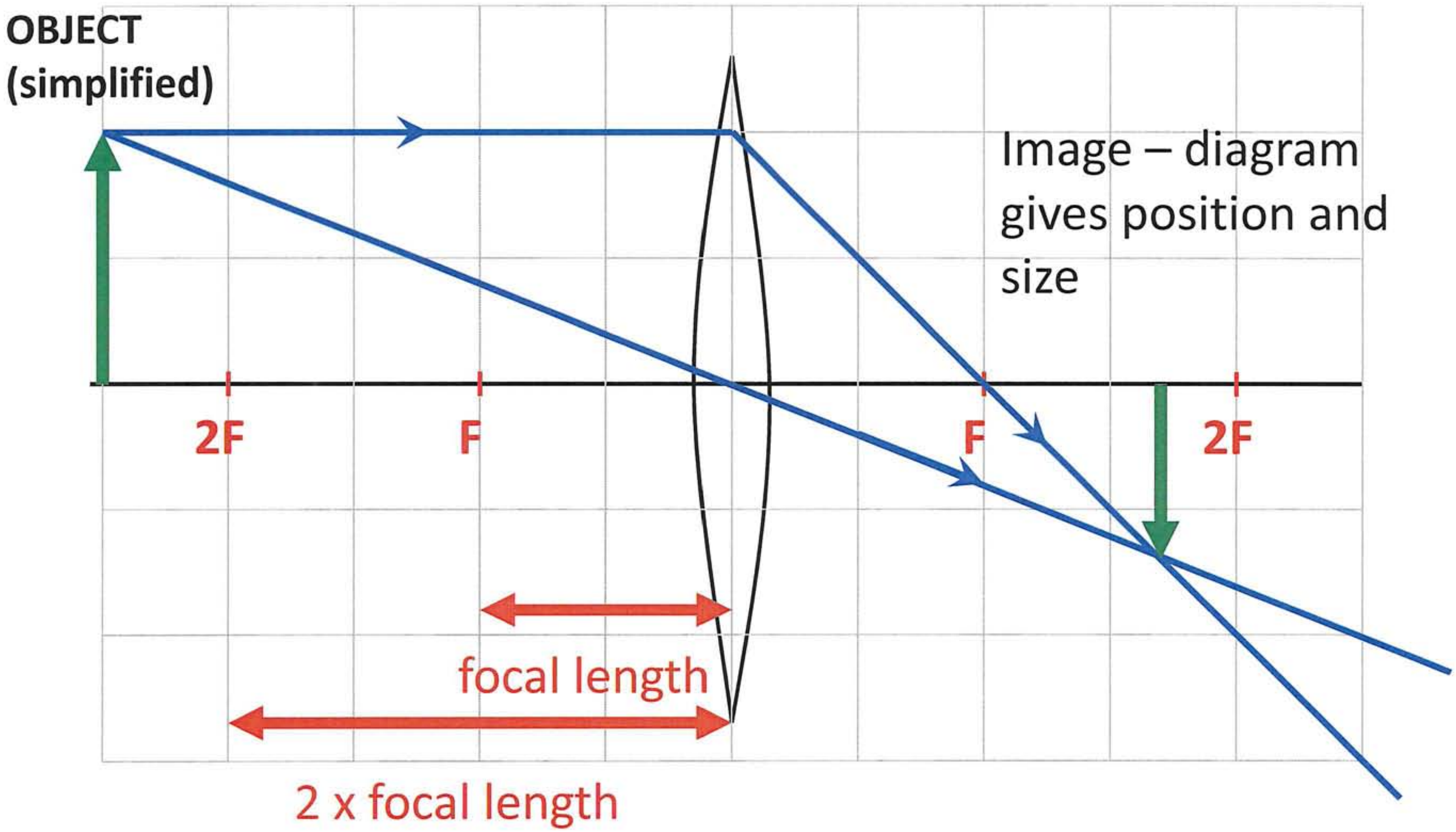
What is the nature of images produced by lenses?

Lenses ______ light and are usually used to form IMAGES

2 types



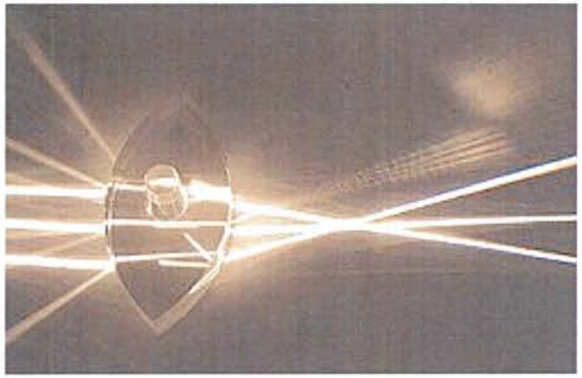
RAY DIAGRAMS:RULES



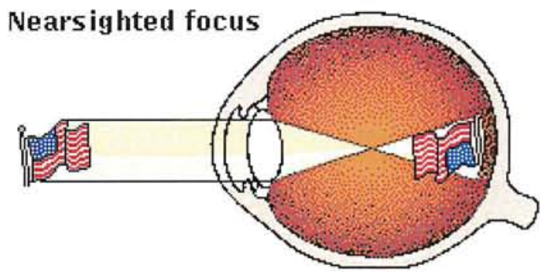
1. A ray ______ to the axis is refracted through the focus
2. A ray to the ______ of the lens passes through undeflected
3. Top of image forms where ______

What is the nature of images produced by lenses?

- A ______ creates a different image depending on the **distance** between the object and the lens



- ______ can be used in ______ to produce an image of an object on a **detecting device** (eg film) and in ______ to focus light onto your **retina**.

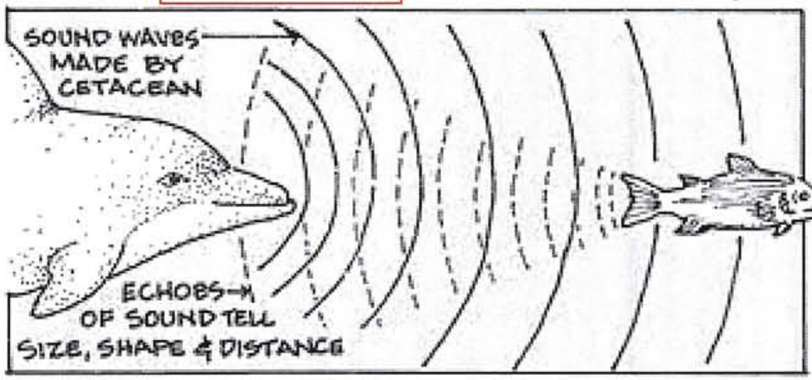


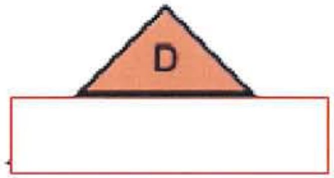
What is sound?

- Sound is caused by ______ and travels as a ______
- Sounds in the range ______ can be detected by the human ear.
- Sound cannot travel through a ______
- The **pitch** of a note **increases** as the ______ **increases**.
- The **loudness** of a note **increases** as the ______ of the wave **increases**.
- The ______ of a note depends upon the **waveform**.
- Sound waves can be ______ and **refracted**.

What is ultrasound?

- Ultrasound waves have a frequency **higher** than the upper limit of ______ (**20kHz**)
- Ultrasound waves are partially ______ when they meet a **boundary** between two different surfaces.
- The **time taken** for the reflections to reach a detector is a measure of how ______ the boundary is.





Distance = ______

- Ultrasound waves can be used in **industry** for ______ and quality control.
- Ultrasound waves can be used in **medicine** for ______

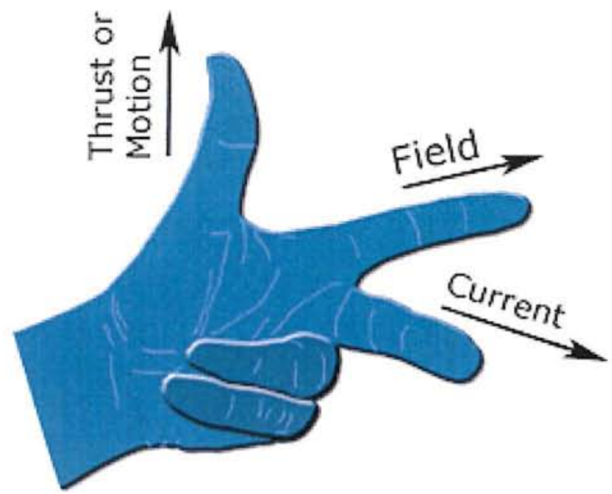
How can electricity make things move?

- When a ____ (wire) carrying an **electric** ____ is placed in a **magnetic field**, it experiences a force. This is called the ____.
- The size of the force can be **increased** by:

– increasing the **strength** of the ____

– increasing the size of the ____

- The conductor will not experience a force if it is ____ to the magnetic field.
- The direction of the force is ____ if either the direction of the **current** or the direction of the **magnetic field** is reversed.
- We can use Fleming's ____ **hand** rule to determine the **direction** of ____ the ____ or ____ ____



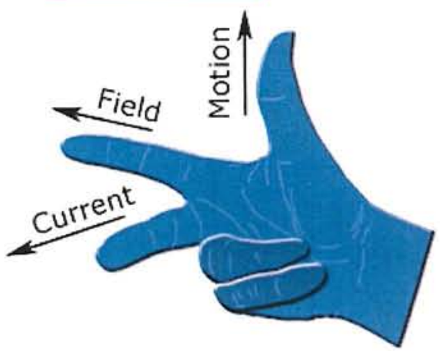
How do generators work?

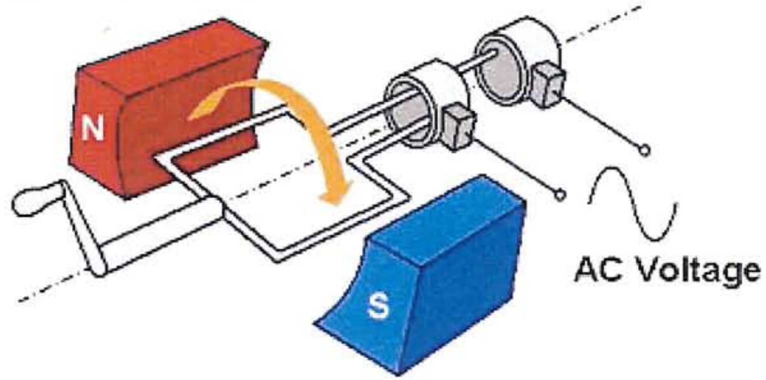
- If an **electrical wire** 'cuts' through ______, an electrical **potential difference** is induced across the ends of the conductor.
- If the conductor is part of a complete circuit, a ______ is **induced** in the wire.
- If the **direction** of motion, or the polarity of the magnet, is **reversed**, the direction of the induced current is ______
- The generator effect also occurs if the **magnetic field** is **stationary** and the ______ is **moved**.
- The size of the induced potential difference increases when:

– the ______ of the movement **increases**

– the **strength** of the magnetic field ______

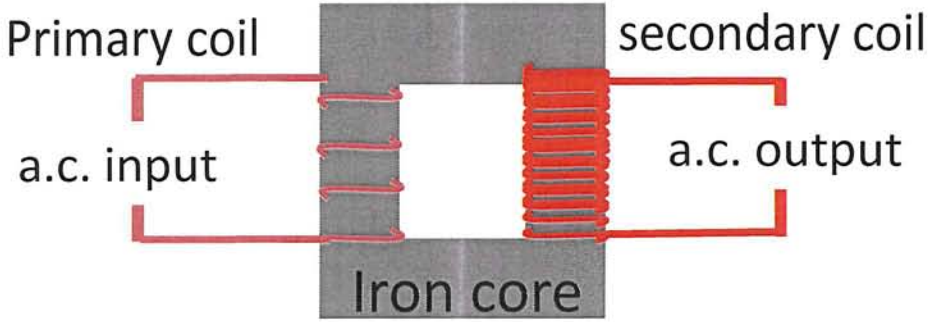
– the ______ of **wire** in the coil **increases**





- Fleming's ______ **hand** rule applies to generators

How do transformers work?



$$\frac{\text{Voltage across the primary coil}}{\text{Voltage across the secondary coil}} = \frac{\text{Number of loops on the primary coil}}{\text{Number of loops on the secondary coil}}$$

- An ______ **current** in the **primary coil** produces a **changing magnetic field** in the **iron core** ______ fore also in the **secondary coil**.
- This induces an **alternating** ______ across the ends of the **secondary coil**.
- In a **step-up** transformer the potential difference across the secondary coil is ______
- In a **step-down** transformer the potential difference across the secondary coil is ______
- Step-up and step-down transformers are used in the **National Grid** to transfer electricity at a higher voltage but ______ reducing wasted ______ energy.

What happens during the life of a star?

- The Universe is made up of billions of **galaxies**. Our Sun is one of billions of ____ in the **Milky Way** galaxy.
- Stars **form** when enough dust and gas from space is pulled together by ____ – a ____ forms.
- **Friction** between particles causes heat ____ which is balanced by **gravity** to make a star ____ (like our Sun).
- ____ processes in stars produce all naturally occurring **elements**.
- These elements may be distributed throughout the Universe by the explosion of a **large** star (____) at the end of its life. It then cools to form a **neutron** star or ____.
- **Smaller** stars expand and cool forming ____ then ____

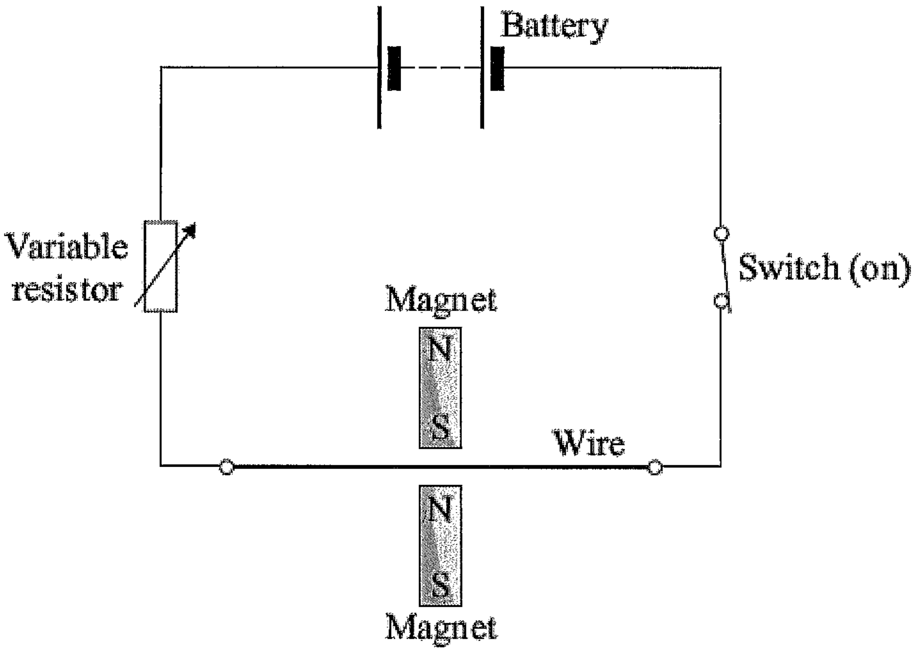
Star like our Sun

A large Star

Q1. A student investigates the electromagnetic force acting on a wire which carries an electric current. The wire is in a magnetic field.

The diagram shows the circuit which the student uses.

(a) Draw an **X** on the diagram, with the centre of the **X** in the most strongest part of the magnetic field.



(1)

(b) Give **one** change that she can make to the magnets to **decrease** the electromagnetic force on the wire.

....

....

(1)

(c) The student wants to change the electromagnetic force on the wire without changing the magnets or moving their position.

(i) Give **one** way in which she can **increase** the electromagnetic force.

....

....

(1)

(ii) Give **one** way in which she can **reverse** the direction of the electromagnetic force.

....

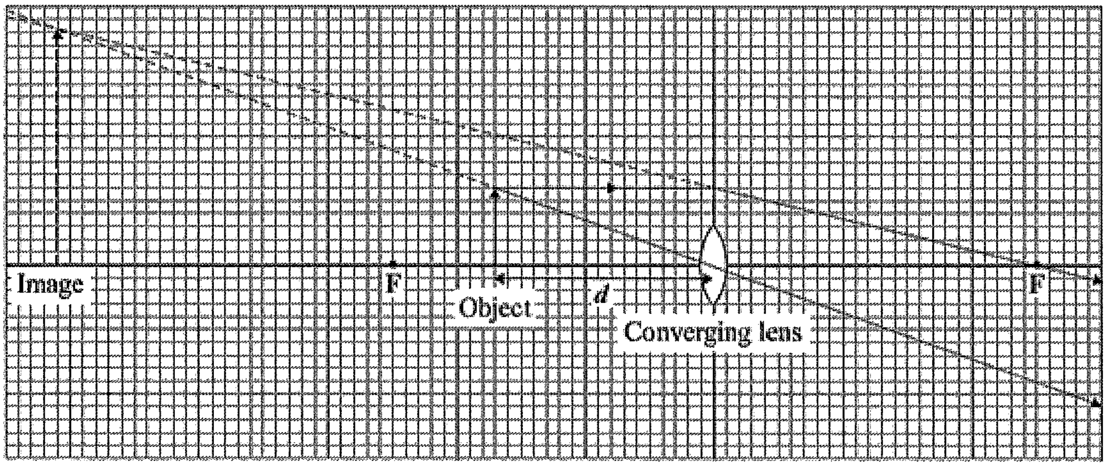
....

(1)

(Total 4 marks)

Q2. A student investigates how the magnification of an object changes at different distances from a converging lens.

The diagram shows an object at distance d from a converging lens.



(a) (i) The height of the object and the height of its image are drawn to scale.

Use the equation in the box to calculate the magnification produced by the lens shown in the diagram.

$$\text{magnification} = \frac{\text{image height}}{\text{object height}}$$

Show clearly how you work out your answer.

....

....

....

Magnification = ...

(2)

(ii) The points **F** are at equal distances on either side of the centre of the lens.

State the name of these points.

....

(1)

(iii) Explain how you can tell, **from the diagram**, that the image is virtual.

....

....

(1)

(b) The student now uses a different converging lens. He places the object between the lens and point **F** on the left.

The table shows the set of results that he gets for the distance d and for the magnification produced.

Distance d measured in cm	**Magnification**
5	1.2
10	1.5
15	2.0
20	3.0
25	6.0

His friend looks at the table and observes that when the distance doubles from 10 cm to 20 cm, the magnification doubles from 1.5 to 3.0.

His friend's conclusion is that:

The magnification is directly proportional to the distance of the object from the lens.

His friend's observation is correct but his friend's conclusion is **not** correct.

(i) Explain, with an example, why his friend's conclusion is **not** correct.

....

....

....

....

(2)

(ii) Write a correct conclusion.

....

....

(1)

(iii) The maximum range of measurements for d is from the centre of the lens to **F** on the left.

The student **cannot** make a correct conclusion outside this range.

Explain why.

....

....

(1)
(Total 8 marks)

Q3. (a) Explain what an ultrasound wave is.

....

....

....

....

(2)

(b) Ultrasound waves can be used to clean jewellery.

One method is to put the jewellery in a bath of cleaning fluid which contains an electronic oscillator. The electronic oscillator generates ultrasound waves in the cleaning fluid.

Suggest how these waves clean the jewellery.

....

....

....

....

(2)

(c) Ultrasound is used for pre-natal scanning. This is much safer than using X-rays. However, doctors were only sure it was safe after experiments on mice.

Explain whether or not you think that these experiments were justified.

....

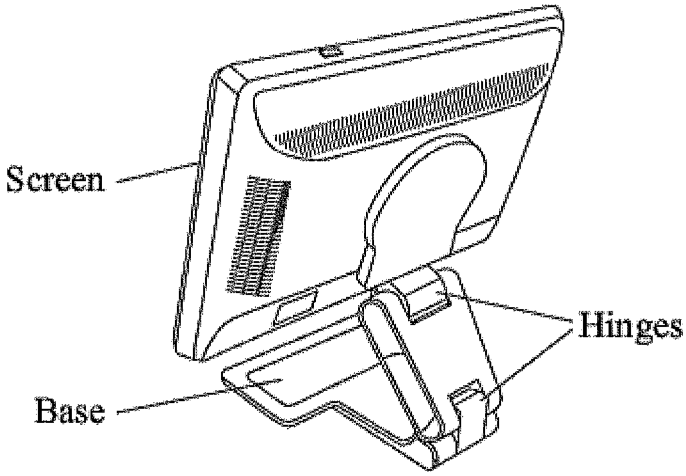
....

....

....

(2)
(Total 6 marks)

Q4. The diagram shows a back view of a computer monitor.



(a) In normal use, the monitor is *stable.*

(i) Explain the meaning, in the above sentence, of the word *stable.*

....

....

....

....

(2)

(ii) State the relationship between the total clockwise moment and the total anticlockwise moment about any axis of the monitor when it is stable.

....

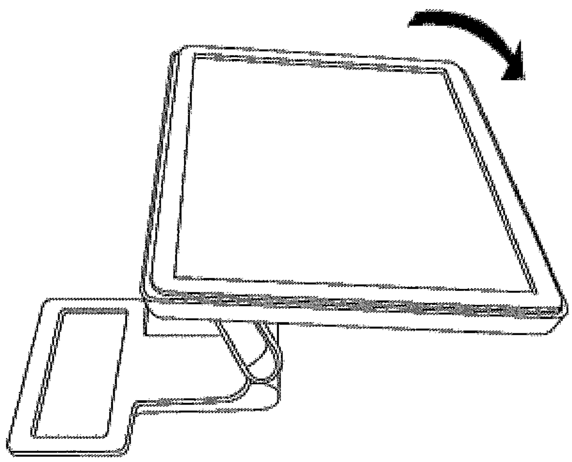
....

(1)

(b) The instruction booklet explains that the screen can be tilted. It also includes a warning.

Caution

The monitor can tip over if the screen is tilted too far back.



Explain why the monitor will tip over if the screen is tilted too far back.

Include the words *centre of mass*, *weight* and *moment* in your explanation.

....

....

....

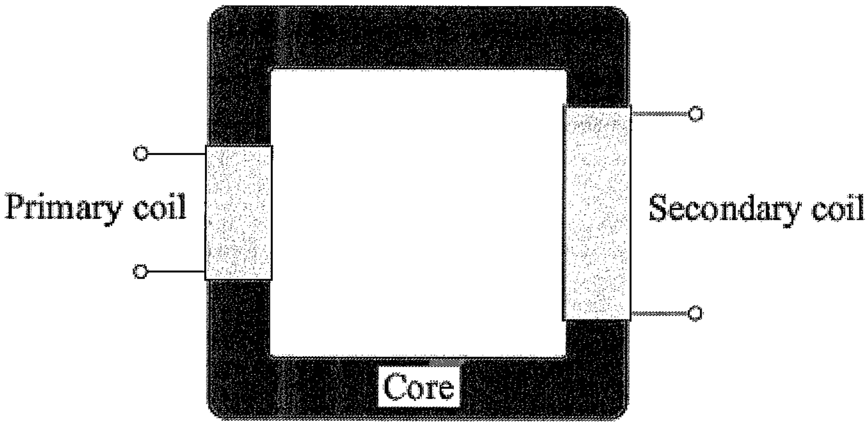
....

....

....

(3)
(Total 6 marks)

Q5. (a) The diagram shows the basic structure of a step-up transformer.



(i) What is the core made of?

....

(1)

(ii) Explain how an alternating input produces an alternating output.

....

....

....

....

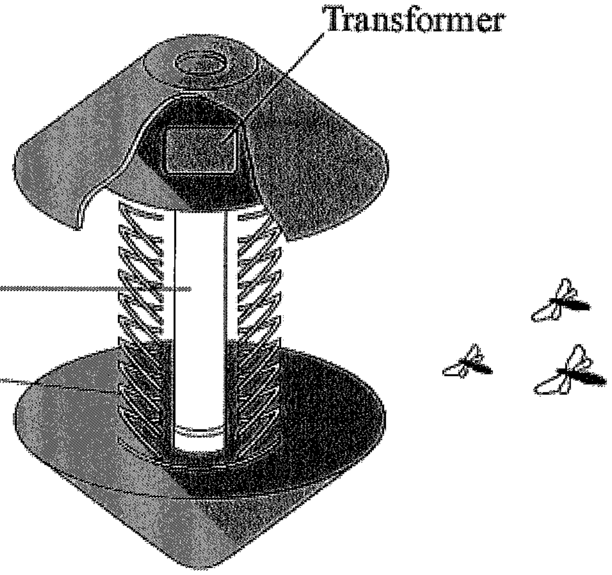
....

....

(3)

(b) Fly killers are used in kitchens and food stores because flying insects carry diseases which cause food poisoning.

The diagram shows the inside of one design. Insects are attracted to a fluorescent lamp. The metal grids have a high potential difference (p.d.) between them. The insects are killed as they fly between the grids.



A transformer is used in the fly killer. There is a p.d. of 230 V across the primary coil. There are 300 turns of wire on the primary coil and 4000 turns on the secondary coil.

Use the equation in the box to calculate the p.d. across the secondary coil.

$$\frac{\text{p.d. across primary}}{\text{p.d. across secondary}} = \frac{\text{number of turns on primary}}{\text{number of turns on secondary}}$$

Show clearly how you work out your answer.

....

....

....

....

....

Potential difference = ...V

(3)
(Total 7 marks)

Q6. (a) Our star, the Sun, is stable.

Explain what the conditions need to be for a star to remain stable.

....

....

....

....

....

....

(2)

(b) Shortly after the 'big bang', hydrogen was the only element in the Universe.

Explain how the other elements came to be formed.

....

....

....

....

....

....

....

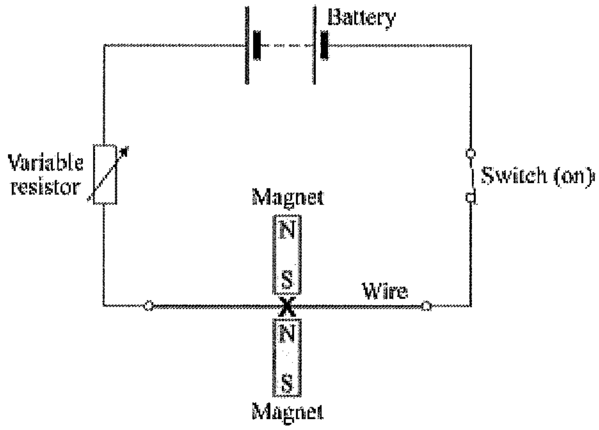
....

(3)
(Total 5 marks)

M1. (a) centre of the **X** midway between the poles

intention correct as judged by eye

example



1

(b) move the poles further apart

accept turn for move

accept ends / magnets for poles

accept use weaker magnets

*do **not** accept use smaller magnets*

1

(c) (i) add more cells (to the battery)

*do **not** accept 'use a bigger battery'*

accept increase the potential difference / voltage

accept increase the current

or

reduce the resistance (of the variable resistor)

*do **not** accept any changes to the magnets, to the wire or to their relative positions*

1

(ii) reverse (the polarity of) the battery

accept turn the battery / cells round

accept swap the connections to the battery

*do **not** accept any changes to the magnets, to the wire or to their relative positions*

1

[4]

M2. (a) (i) answer in the range 3.0 ↔ 3.1 inclusive

accept for 1

3.6 ÷ 1.2 or 3.7 ÷ 1.2
or 36 ÷ 12 or 37 ÷ 12
or 18 ÷ 6 or 18.5 ÷ 6
or 10.2 ÷ 3.4 or 102 ÷ 34
or answer in the range but with a unit eg 3 cm

2

(ii) (principal) focus / focal (point(s)) / foci / focus
accept 'focusses'
accept focals
*do **not** accept focal length*

1

(iii) at the intersection of virtual / imaginary rays
***or** 'where virtual / imaginary rays cross'*
***or** the rays of (real) light do not cross*
***or** the image on the same side (of the lens) as the object*
***or** the image is drawn as a dotted line*
***or** the image is upright*
*do **not** accept 'cannot be put on a screen'*
*do **not** accept any response which refers to reflected rays*

1

(b) (i) another correct observation about relationship between values of **d** (1)

(but) not the same relationship between corresponding values for magnification (1)
example
15 is three times bigger than 5 but
2.0 is not three times bigger than 1.2

2

(ii) when the distance / **d** increases the magnification increases
***or** the converse*
accept 'there is a (strong) <u>positive</u> correlation'
*do **not** accept any response in terms of proportion / inverse proportion*

1

(iii) (student has) no evidence (outside this range)
accept data / results / facts for 'evidence'

1

[8]

M3. (a) sound / mechanical / longitudinal (wave) 1

any **one** from:

- above 20 000 hertz / 20kHz
- above (human) audible range
- cannot be heard by humans

1

(b) **either**

particles / molecules / fluid vibrate(s) (1)

(and) knock particles of dirt off the jewellery (1)

or

by the process of cavitation (1)

accept 'formation and collapse of tiny bubbles'

which breaks up / releases dirt from the surface (1)

2

(c)***either*** *both pro*

or *both con*

or *one of each*

either

two appropriate points gain **1** mark each

or

one appropriate point (and) appropriate qualification / amplification

examples

other mammals (sufficiently) similar to humans (1)

so results appropriate (1)

unethical to experiment on humans (1)

so it is better to experiment on mice (1)

knowledge / techniques will benefit humans (1)

and also other animals (1)

experiments were justified because ultrasound has proved useful (1)

2

[6]

M4. (a) (i) will not fall over (1)

accept will not easily fall over (2)

orcentre of mass will remain above the base (1)

(line of action of the) weight will remain above within the base

accept centre of gravity / c of g / c of m / c m

if the monitor is given a small push (1)

depends on mark above

2

(ii) (total) clockwise moment = (total) anticlockwise moment

***or** they are equal / balanced*

1

(b) the position of the <u>centre of mass</u> has changed (1)
the line of action of the <u>weight</u> is outside the base (1)
producing a (resultant) <u>moment</u> (1)

points may be expressed in any order

3

[6]

M5. (a) (i) (laminated soft) iron

*do **not** accept steel*

1

(ii) produces a <u>magnetic field</u>

accept <u>magnetic flux</u>

which is alternating / changing / varying

and which induces / produces an alternating / changing potential difference across the <u>secondary</u> coil

accept current / voltage

3

(b) 3067 (V)

*allow all **3** marks for 3060 to 3070 (V)*

$V = \frac{230 \times 4000}{300}$ *gains **2** marks*

$\frac{230}{V} = \frac{300}{4000}$ *gains **1** mark*

3

[7]

M6. (a) gravitational force(s) (1)

accept 'gravity'

balanced by (force(s) due to) radiation pressure (1)

accept equal

2

(b) by (nuclear) fusion (1)

of hydrogen to helium (other light elements) (1)

allow 'low density' for light

accept hydrogen nuclei / atoms form helium

response must clearly link one element(s) producing others

fusion to produce helium (2)

heavy element / elements heavier than iron are only produced (by fusion) in a supernova (1)

allow dense for heavy

ignore any reference to elements undergoing radioactive decay (to form other elements)

3

[5]