AQA P3 Topic 1

Medical applications of Physics

X rays

X-ray properties

- X-rays are part of the electromagnetic spectrum.
- X-rays have a wavelength of the same order of magnitude as the diameter of an atom.
- X-rays are ionising.
- Different materials absorb different amounts of x-rays
- **Denser material = more absorption = looks lighter on the x-ray photo**

X-rays

- X-rays use charged-couple devices (CCDs) to produce an image electronically.

CT Scans

- X-ray source moves in **circle** around patient
- Detectors opposite the source
- Many **cross-sectional images** that can build up 3D image
- **Tumours** detected with areas of brightness or dark patches
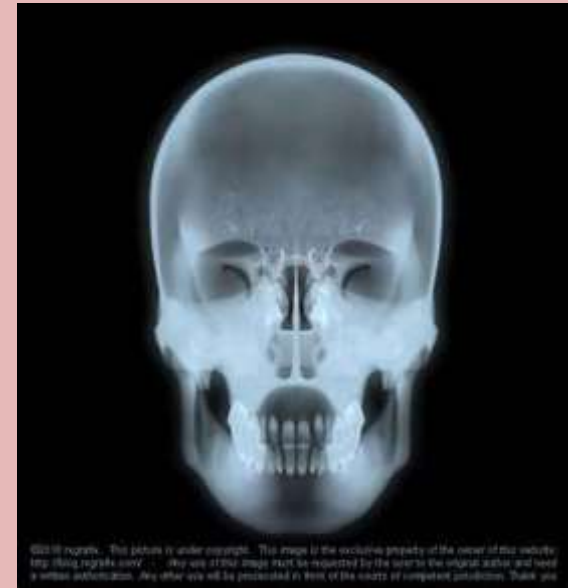
Benefits

- ➢ **Painless** and **non invasive**
- ➢ Can eliminate the need for biopsy to decide on treatment.
- ➢ Can be used to destroy tumours at or near the surface of the body.

Risks

- ❑ Both give a dose of radiation equivalent to **10 yrs background radiation**
- ❑ Increased risk of cancer so not recommended on **children** or **pregnant females**.

Ultrasound

Ultrasound

- Humans detect sound waves between 20 – 20,000Hz

- Above 20,000Hz = **Ultrasound**

- Some **animals** use it to **communicate** (dolphins)

Ultrasound Scan

- Make images of things inside the body

- Ultrasound waves are partially reflected when they meet a boundary between two different media (types of body tissue).

- Ultrasound is non-ionising so it is safer than an X-ray for use in scanning.
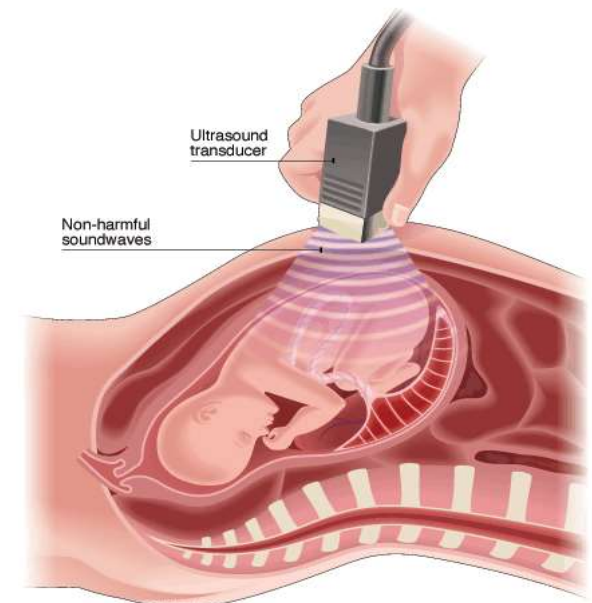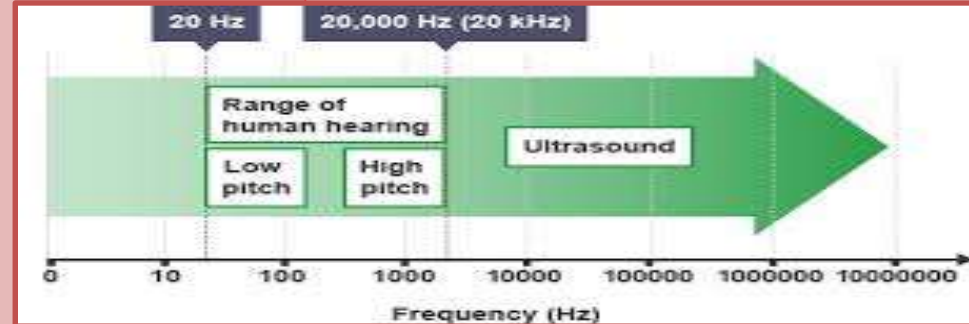
Distance measurements

- The distance between interfaces in various media can be calculated using;

  s = v x t where s= distance in metres, m

  v= speed in meters per second, m/s

  t = time in seconds, s

Use in medicine

- Pre-natal scanning and the removal of kidney stones.

Refractive index

Refraction

- Is the change of direction of light as it passes from one medium to another.
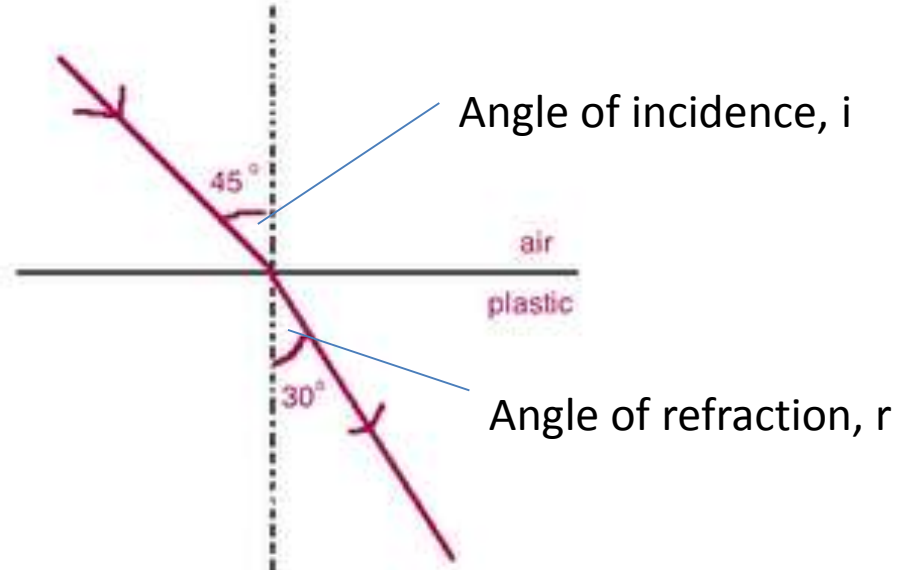
Refractive index

The refractive index of a material, n, is a measure of how much a substance can refract a light ray.

$$n = \frac{\sin i}{\sin r}$$

n = refractive Index
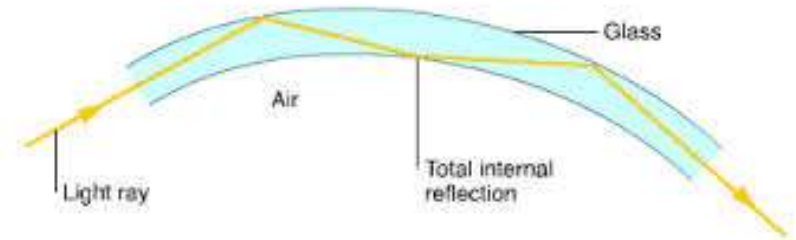i = angle of incident
r = angle of refraction

Angle of incidence, i

45°

air

plastic

30°

Angle of refraction, r

Other applications using light

Optical Fibre

Light ray is **consistently totally internally reflected** as it is at an angle **greater** than the **critical one**.

Endoscope – look **inside** a patient.

- ❑ Flexible rod of **optical fibres**.
- ❑ Used to see inside the body directly.

Glass

Air

Light ray

Total internal reflection

Critical angle

The critical angle is the angle of incidence of a light ray in a transparent substance that produces **refraction along the boundary.**

Refraction

c

Critical angle (c)

Total internal Reflection
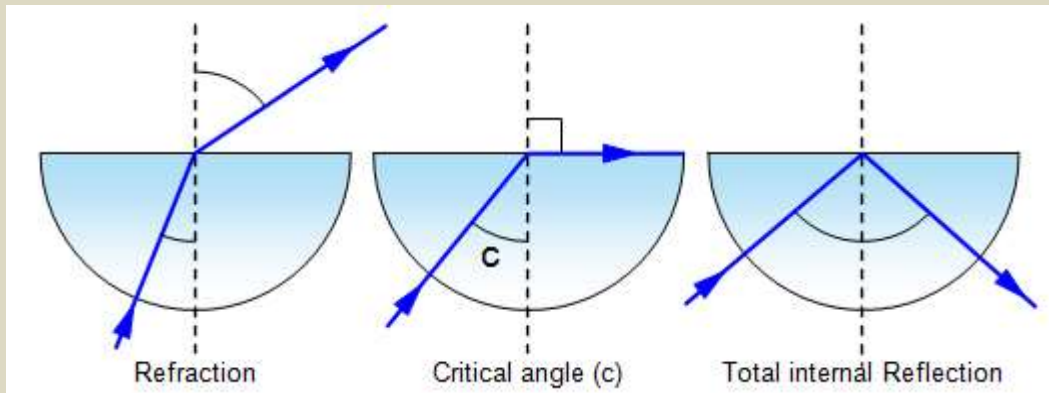
$$n = \frac{1}{\sin c}$$

Refractive index

Critical angle

Lenses

Power of a lens = $\dfrac{1}{\text{Focal length(metre, m)}}$
(dioptre, D)

- **Lenses** are optical devices that bend light by **refraction**:
- In a **converging** (convex) lens, the light rays come together.
- In a **diverging** (concave) lens, the light rays spread apart.

In ray diagrams a convex lens will be represented by:

A concave lens will be represented by:

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

A **real** image can be projected onto a screen. A **virtual** image cannot be projected onto a screen. **Magnified** means made bigger, while **diminished** means made smaller. **Inverted** means turned upside down.

Converging Lenses

- **Converging** lens – parallel rays refracted and **meet** at focal point
- Lens to focal point = **focal length**

The **focal length** is the distance between the **focus** and the **lens axis**. This is given the code *F*. So *2F* means twice the focal length.
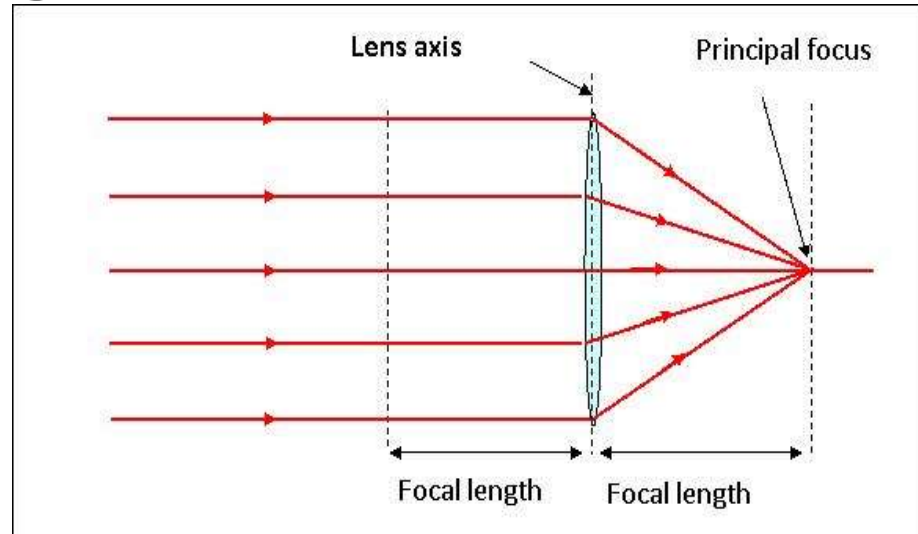
Object at	Image at	Size	Orientation	Nature	Use
Infinity	*F*	Diminished	Inverted	Real	Image on a film (at infinity)
>2F	Between *F* and *2F*	Diminished	Inverted	Real	Image on a film (close up)
2F	*2F*	Same size	Inverted	Real	Photocopier
Between *2F* and *F*	*>2F*	Magnified	Inverted	Real	Projector
F	Infinity	Magnified	Inverted	Real	Spot light
<F	*<F* (on same side)	Magnified	Upright	Virtual	Magnifying glass

Diverging Lenses

➢ **Diverging** lens – focal point is point rays seem to **coming from**

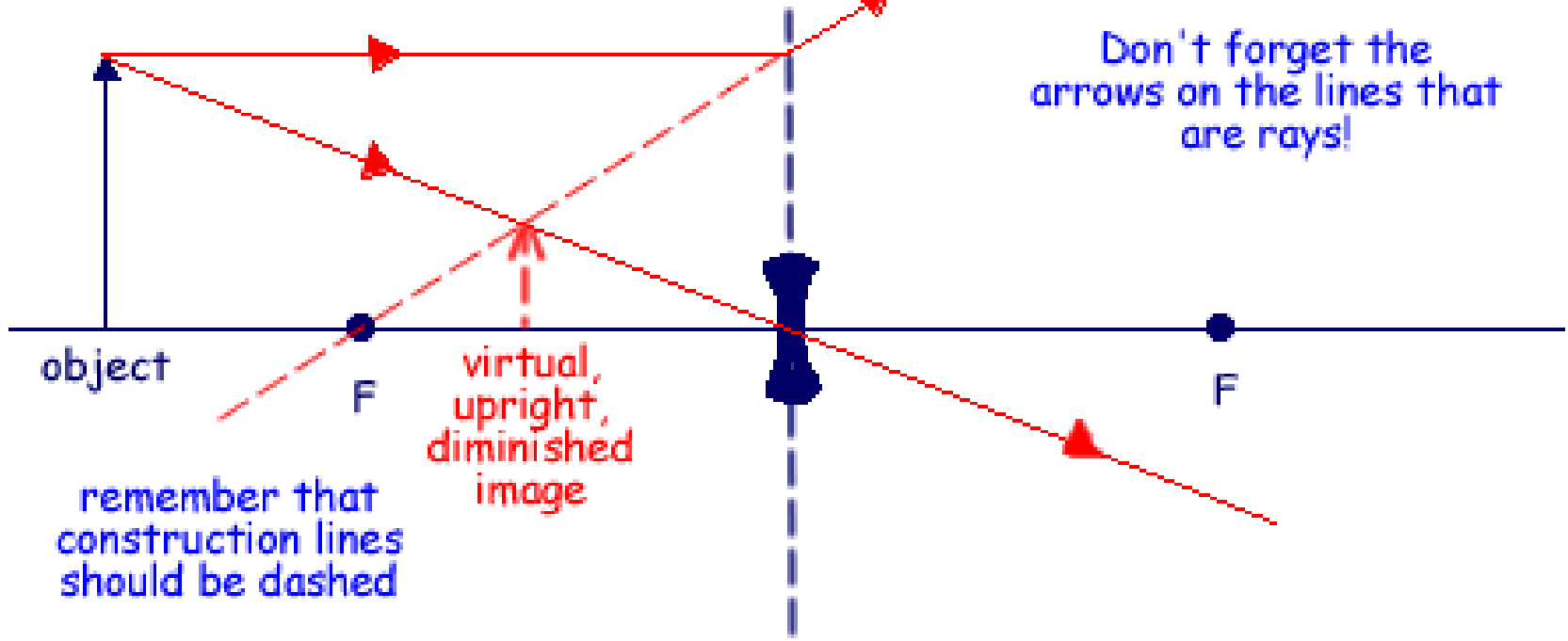➢ Focal point to lens = **focal length**

Lens Axis

Principal focus
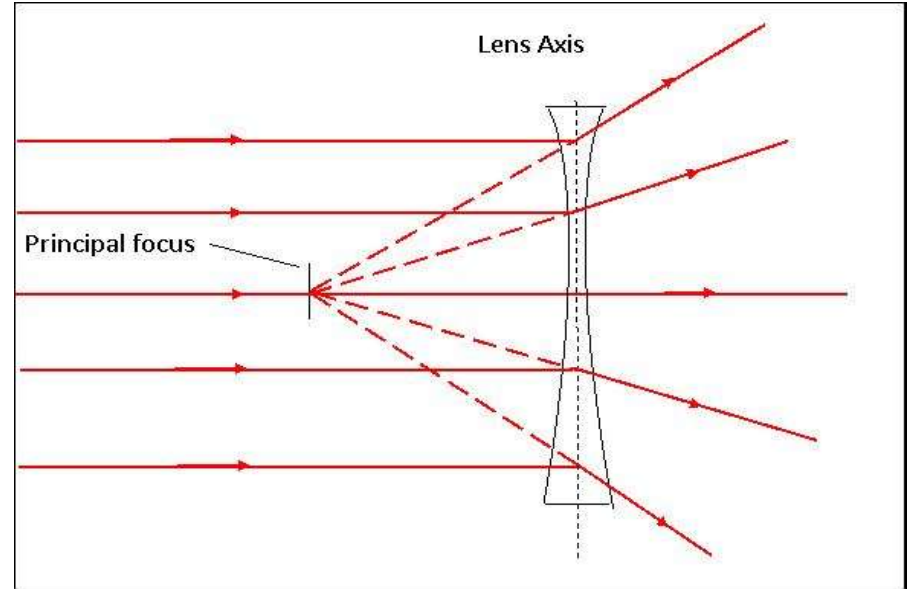
Ray Diagrams for Converging Lens
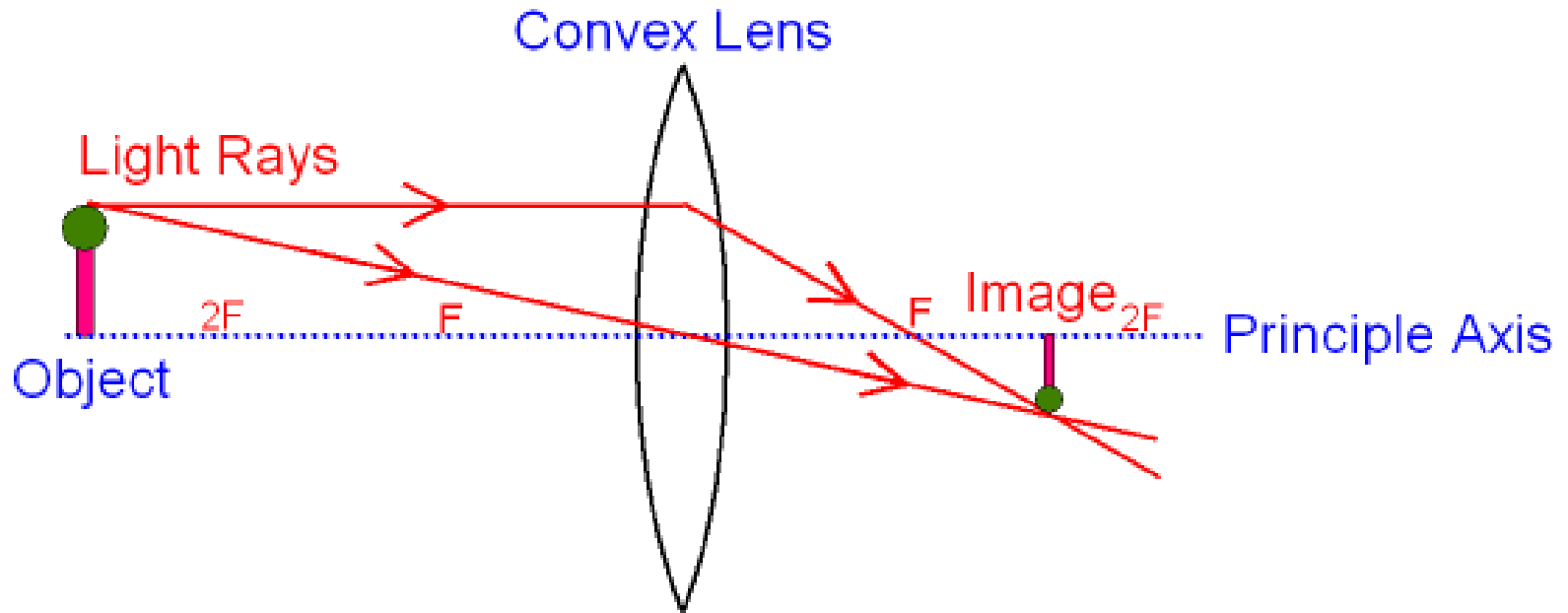
1) Draw the principal axis and the lens (always shown as a line with arrowheads)
2) Draw the object (drawn as a vertical arrow going upwards)
3) Draw a line straight through the principal axis and the lens line (Does not refract)
4) Draw a line parallel to the principal axis that refracts at the lens and goes through the focal point
5) Draw the object on the other side of the lens where both lines cross.
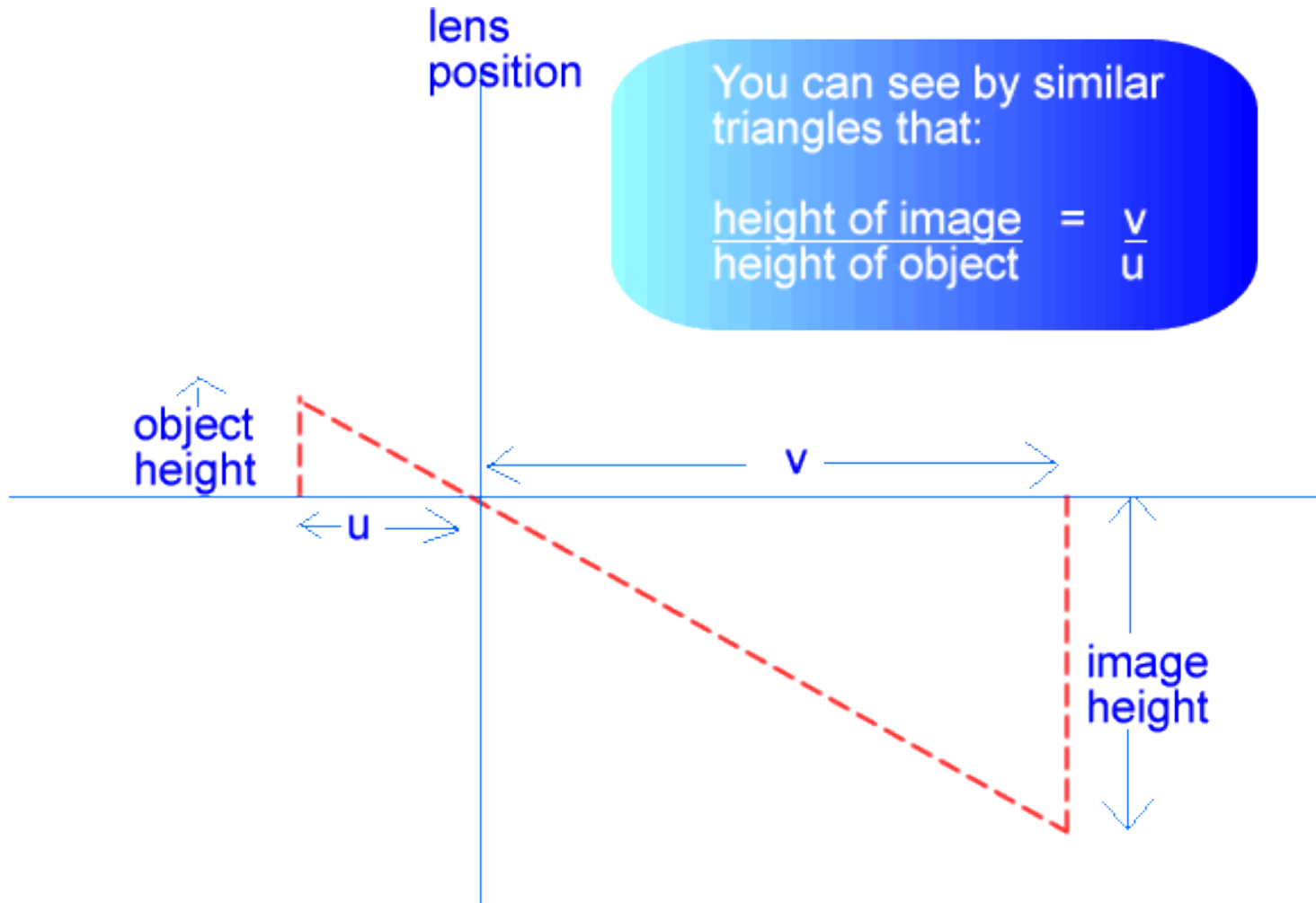
Ray Diagrams for Diverging lens

Don't forget the arrows on the lines that are rays!

object

F

virtual, upright, diminished image

remember that construction lines should be dashed

F

1) **Draw the principal axis and the lens (always shown as a line with arrowheads)**
2) **Draw the object (drawn as a vertical arrow going upwards)**
3) **Draw a line straight through the principal axis and the lens line (Does not refract)**
4) **Draw a line parallel to the principal axis that refracts as if it came from the focal point on the same side as the object.**
5) **Draw a dotted line (this is a virtual ray) to show where the ray appears to come from.**
6) **Draw the object where the virtual ray crosses the first ray. (Image will be virtual)**

Magnification

The **magnification** of a lens is the ratio of the size of the image to the size of the object (how many times bigger the image is than the object was!). If the ratio is greater than 1 the image is bigger than the object (enlarged) and if it is less than 1 it is smaller than the object (diminished in size).

$$M = \frac{v}{u}$$

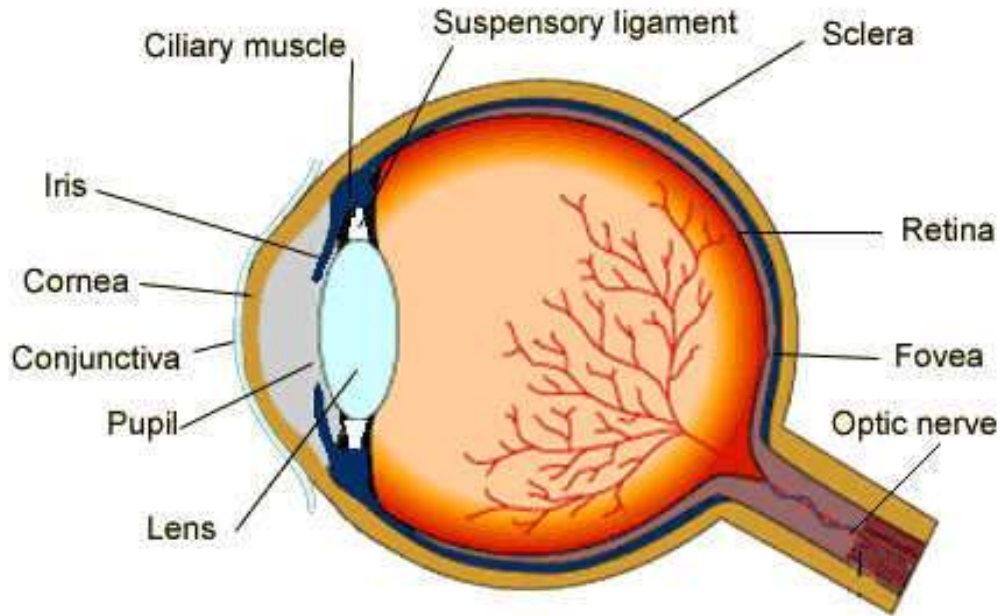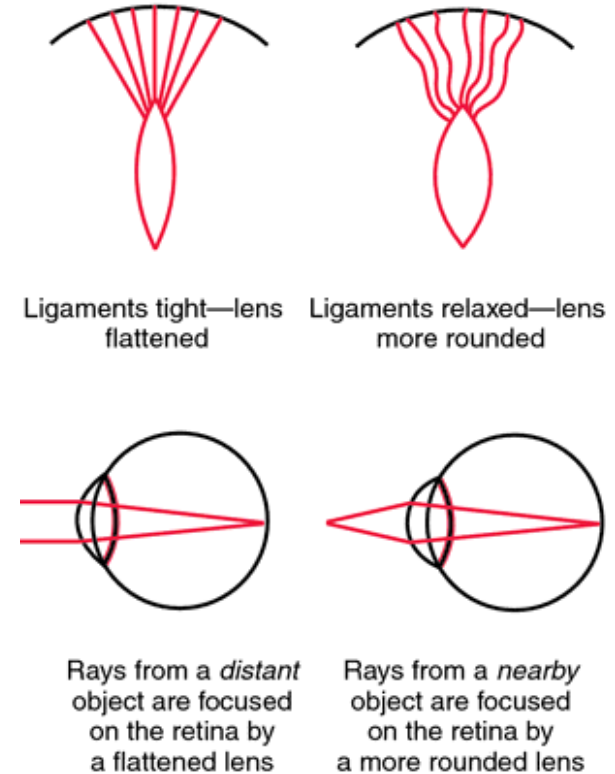**Since *v* is in metres, and *u* is in metres, M has no units**

lens position

You can see by similar triangles that:

$$\frac{\text{height of image}}{\text{height of object}} = \frac{v}{u}$$

object height

v

←u→

image height

The Eye

Image formation

- Light **converges** on the retina
- Path of rays is changed by the eye by **refraction** (carried out by cornea and lens)
- **Ciliary muscles** change the shape of the lens to keep image focussed on retina if the distance alters.
    - Contracted ciliary muscles = loose ligament = lens more rounded = focus on nearby objects
    - Relaxed ciliary muscles = taut ligaments = lens flattened = focus on distant objects
- No limit to how far away you can focus – **far point** is at **infinity**
- You near point is approx. **25cms** – nearer and image is **blurred**.

Eye structure diagram

Ciliary muscle
Suspensory ligament
Sclera
Iris
Cornea
Conjunctiva
Pupil
Lens
Retina
Fovea
Optic nerve

Accommodation/ Focussing

Ligaments tight—lens flattened

Ligaments relaxed—lens more rounded

Rays from a *distant* object are focused on the retina by a flattened lens

Rays from a *nearby* object are focused on the retina by a more rounded lens

The Eye

Normal eye

Myopia
Light focused in front of retina
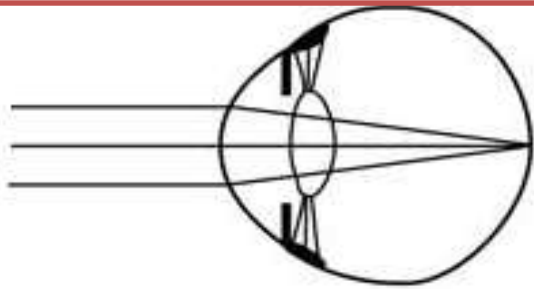
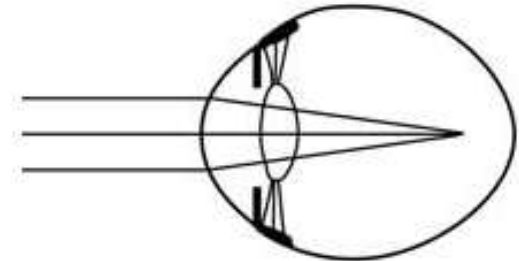In a normal eye, the lens focuses the image exactly on the retina.

However, in the eye of a person with Myopia **(short sighted),** the image is formed before the retina. This leads to a blurred image.
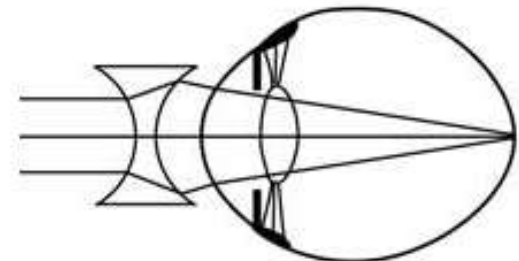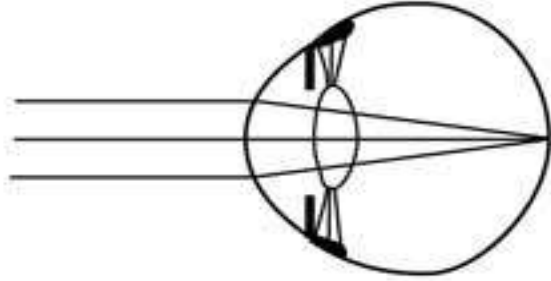

Myopia
Light focused in front of retina

Corrected with concave lens
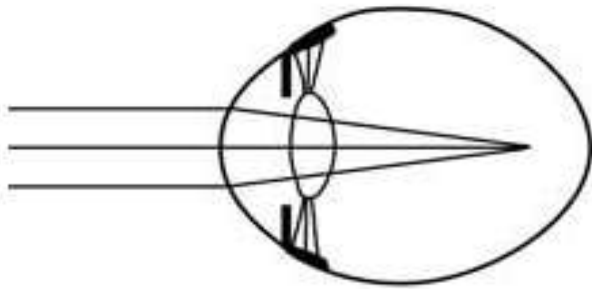
Short sight can be corrected by glasses that have a **concave (diverging) lens.** This causes the light rays to diffract outwards slightly as they pass the lens so that they are focused exactly on the retina by the lens in the eye.

The Eye

Normal eye

Hypermetropia

Light focused behind the retina

In a person with 'hyperopia' **(long sight),** the image is not correctly focused onto the retina by the eye lens. The image is focused behind the retina, leading to a blurry image.
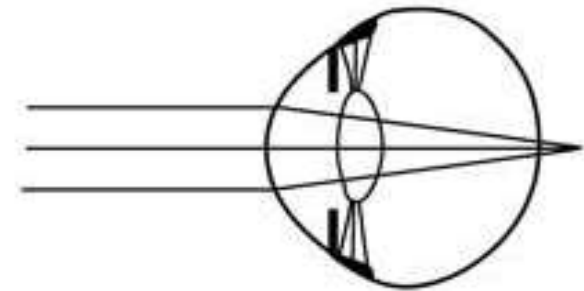
Hypermetropia

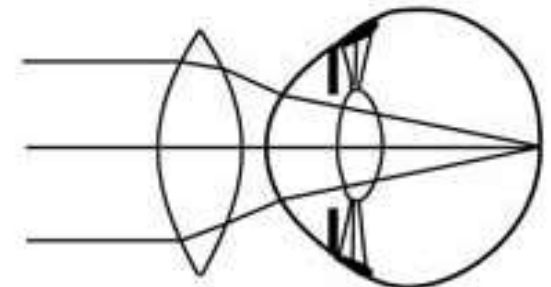Light focused behind the retina
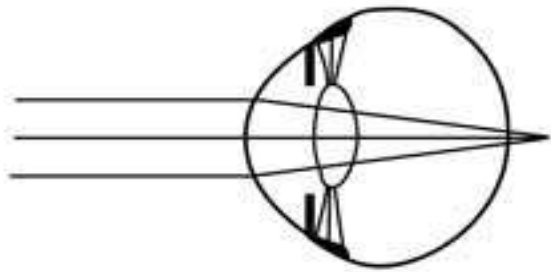
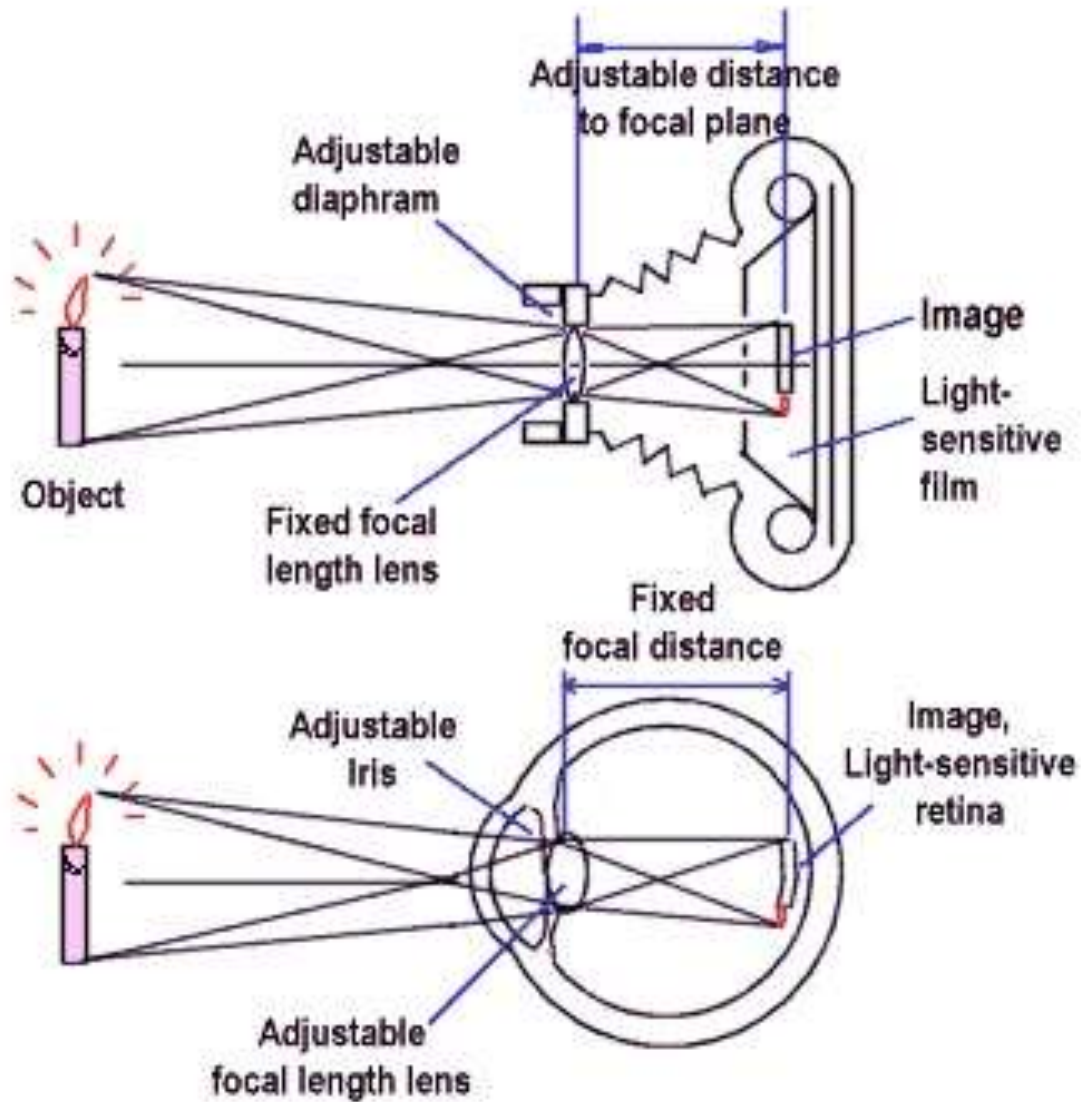Long sight can be corrected by using a **convex (converging) lens**. This causes the light rays to converge slightly before they hit the lens so that they are refracted perfectly onto the retina.
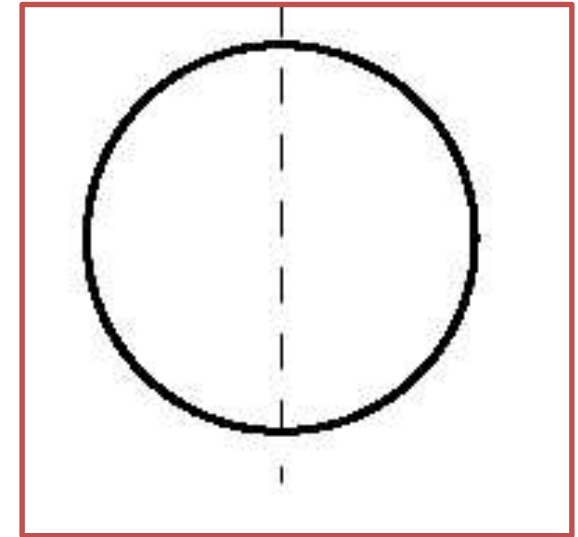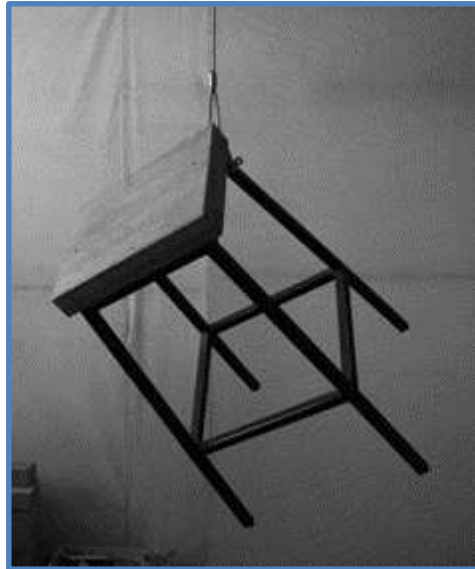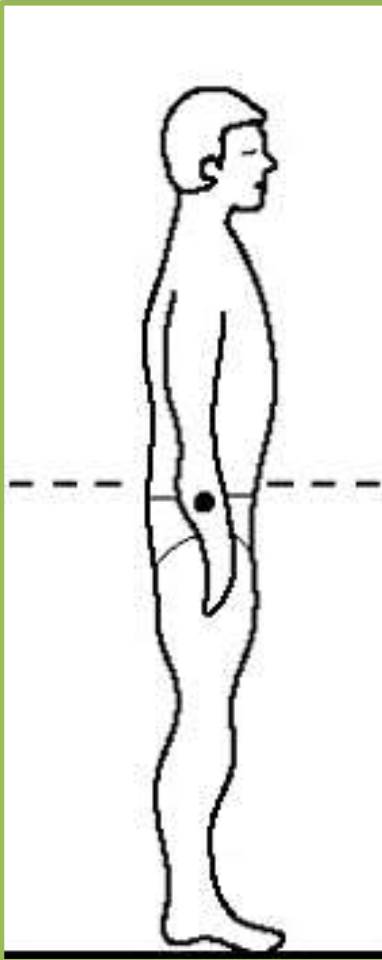
Corrected with convex lens

The Eye

AQA P3 Topic 2

Using Physics to make things work

Centre of Mass

The centre of mass of an object is that point at which the mass may thought to be concentrated.
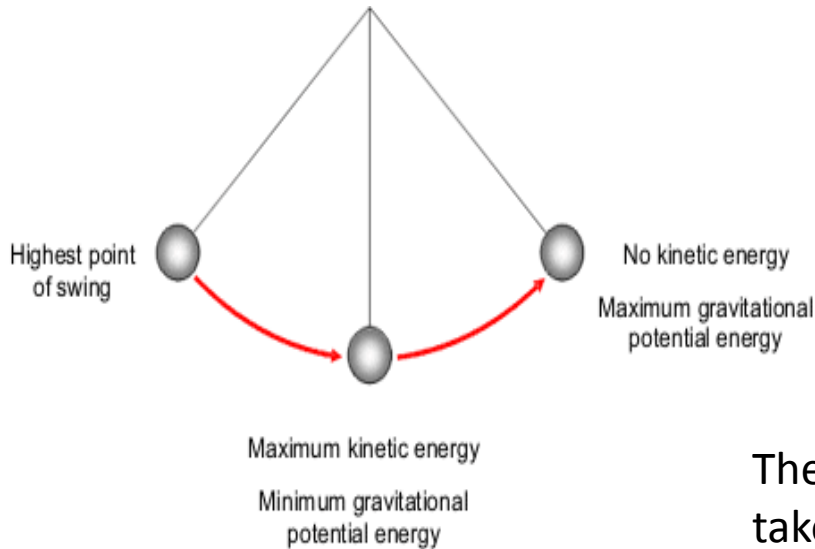
The centre of mass of symmetrical objects **ALWAYS lies along the line of symmetry of the object.**

If you suspend an object and then release it, it will soon come to a rest. When this happens, the centre of mass will be directly below the point of suspension. The object can be said to be in equilibrium.

Pendulum

The pendulum moves backwards and forwards and always returns back to the middle, called the **equilibrium position**. This type of motion is called **oscillating motion**.

Highest point of swing

No kinetic energy

Maximum gravitational potential energy

Maximum kinetic energy

Minimum gravitational potential energy

The time period of a pendulum is the time it takes for a pendulum to complete one full cycle of motion. The easiest way to measure this is the **time it takes for the pendulum to swing from one side of the pendulum to the other side and back again.**

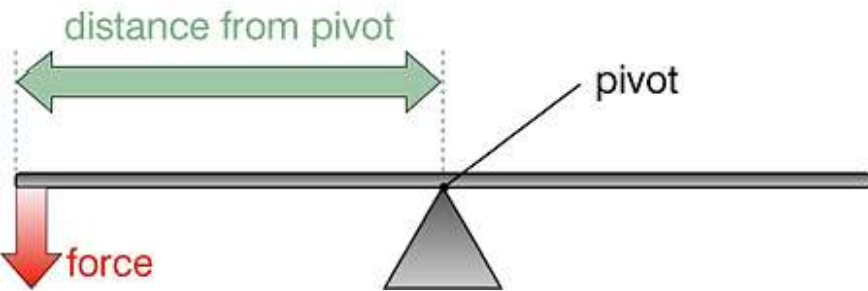The factors that affect the time period of a pendulum are:
1. **The length of the pendulum**
2. **The amplitude (maximum displacement) of the swing**

The time period of a pendulum can be calculated using the following formula:

$$T = 1 / f$$

T = Time (s)
f = frequency (Hz)

Moments

distance from pivot

pivot

force

The turning effect of a force is called a moment

Moment = force (N) x distance from pivot (m)

m = f x d

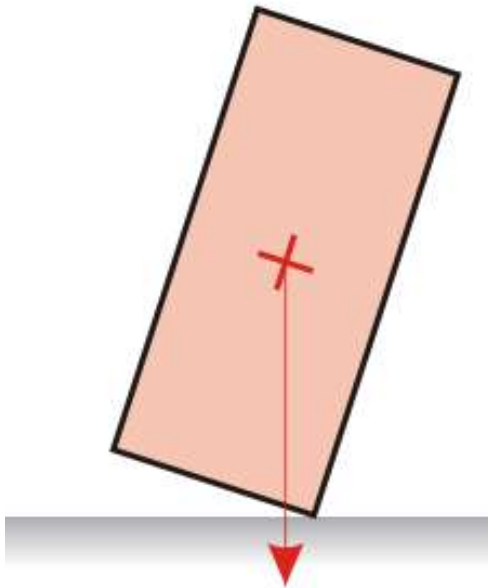**A seesaw is an example of the principle of moments. This states that for an object in equilibrium (not moving!) the sum of all the clockwise moments about any point is equal to the sum of all the anticlockwise moments about the same point.**

Clockwise moments = anticlockwise moments

$$W_1 \times D_1 = W_2 \times D_2$$

Person B

Person A

2 m

1 m

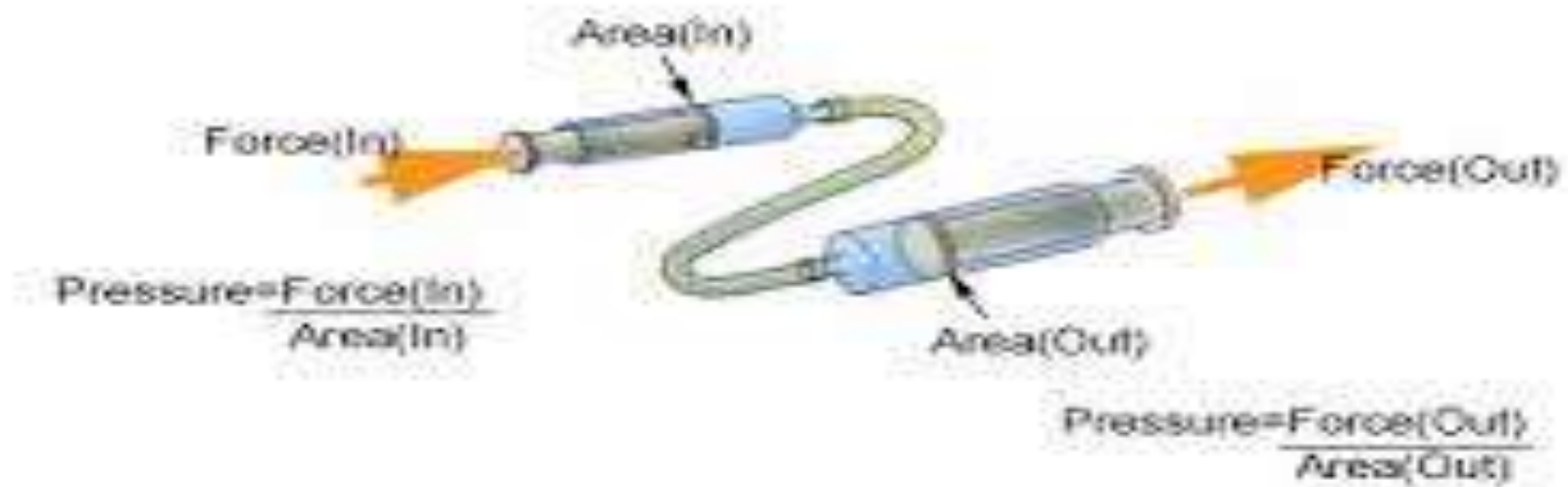500 N

1000 N

Pivot (fulcrum)
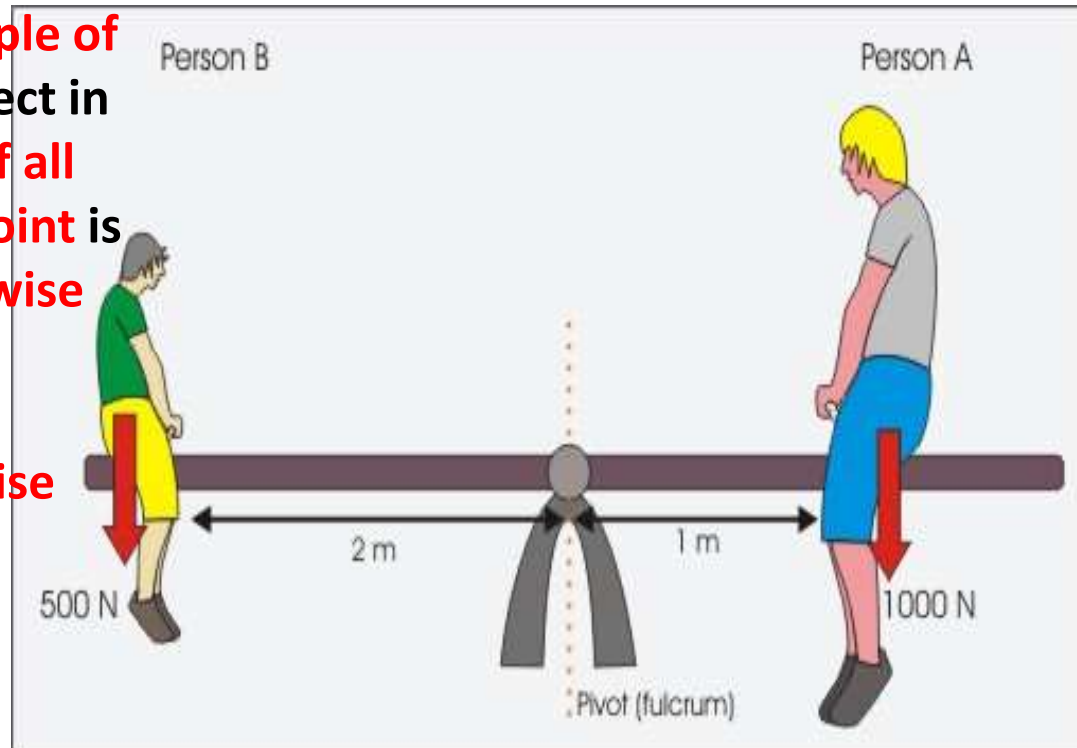
Stability

The weight of an object acts through the centre of mass. As the object is initially tilted, the weight is causing an **anticlockwise moment about the pivot**. If the object is let go, the moment will cause the object to go back onto its base.

When the object has been tilted beyond a certain point, the weight will now cause a **clockwise moment about the pivot**. If the object is let go, the moment will cause the object to topple over!
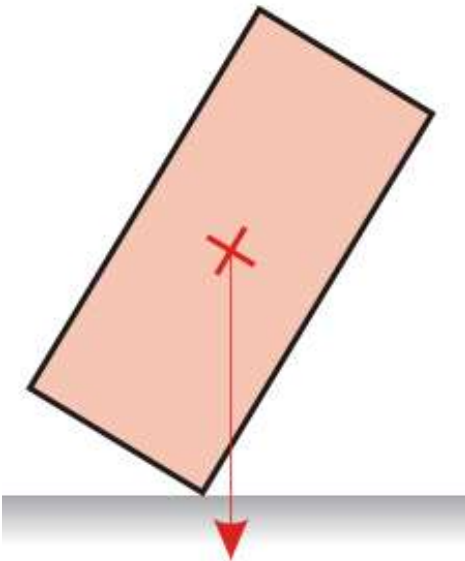
If the line of action of the weight of an object lies outside the base of the object there will be a resultant moment and the body will tend to topple.

Hvdraulics

Area(In)

Force(In)

Force(Out)

$$\text{Pressure} = \frac{\text{Force(In)}}{\text{Area(In)}}$$

Area(Out)

$$\text{Pressure} = \frac{\text{Force(Out)}}{\text{Area(Out)}}$$

Pressure is the same throughout the system,

$$\text{So} \quad \frac{\text{Force(In)}}{\text{Area(In)}} = \frac{\text{Force(Out)}}{\text{Area(Out)}}$$

**Pressure = pascals (Pa)**
Force = Newtons (N)
•Area = metres² (m²)

Liquids are **almost incompressible**. This means that if a force is applied to liquid in one part of the system, it will move and transfer the force to another part of the system.

Circular Motion

When an object 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.
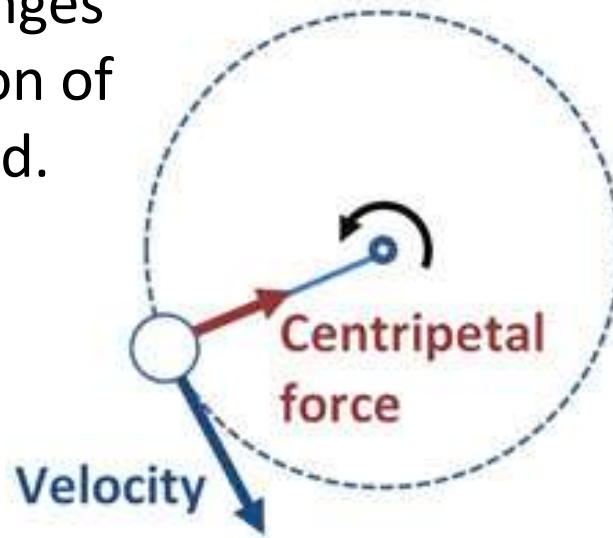
The resultant force causing this acceleration is called the centripetal force and is always directed towards the centre of the circle.
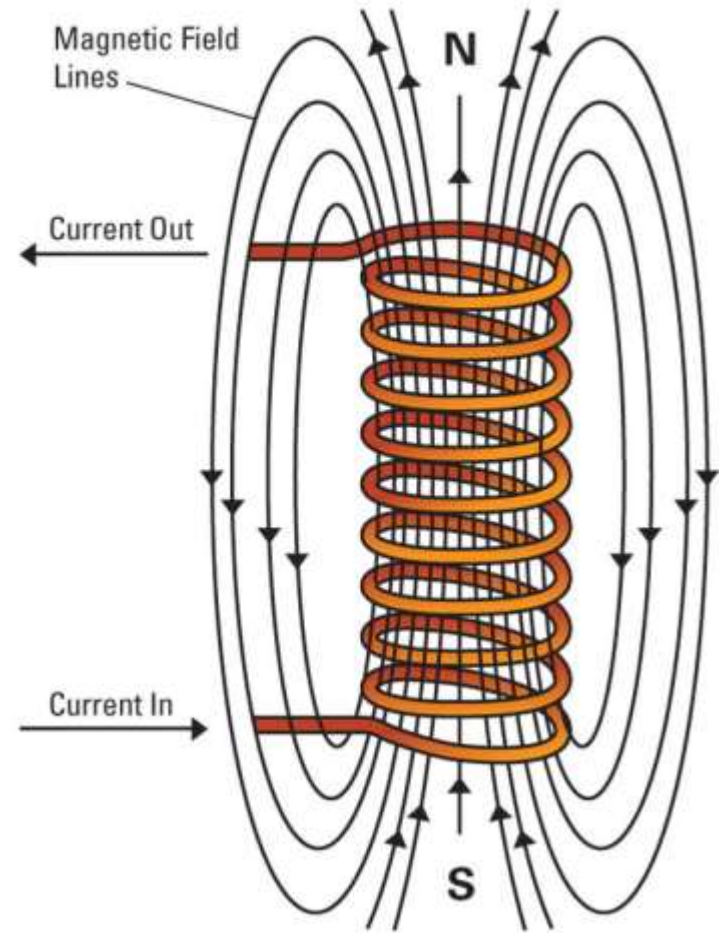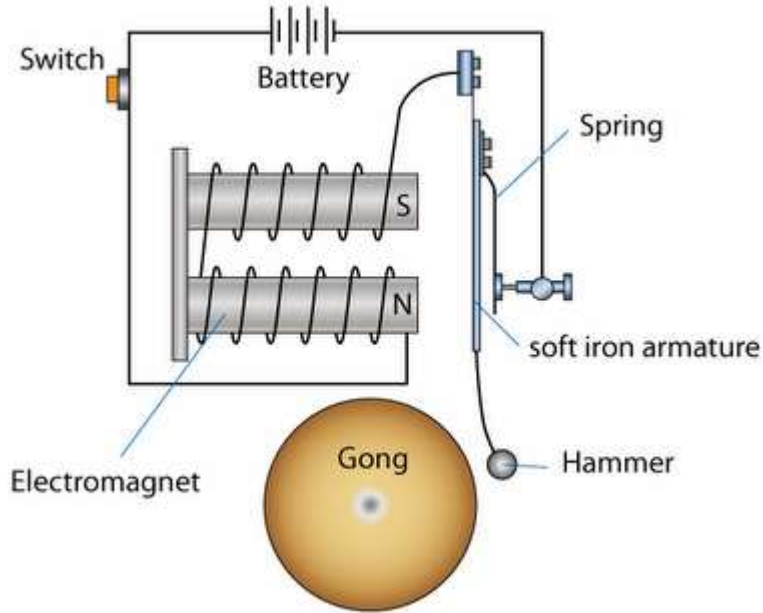

Centripetal force

Velocity

The centripetal force needed to make an object perform circular motion increases as:
•The mass of the object increases.
•The speed of the object increases.
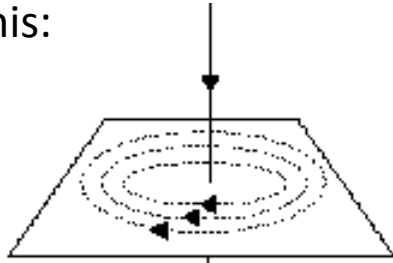•The radius of the circle decreases.

AQA P3 Topic 3

Keeping things moving

Electromagnets

Switch

Battery

Spring

S

N

soft iron armature

Electromagnet

Gong

Hammer

Magnetic Field Lines
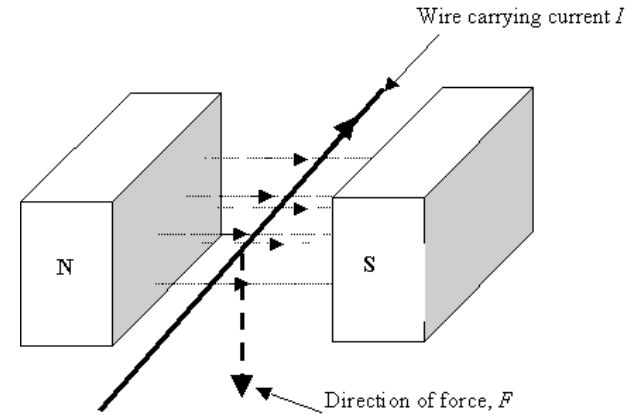
N

Current Out

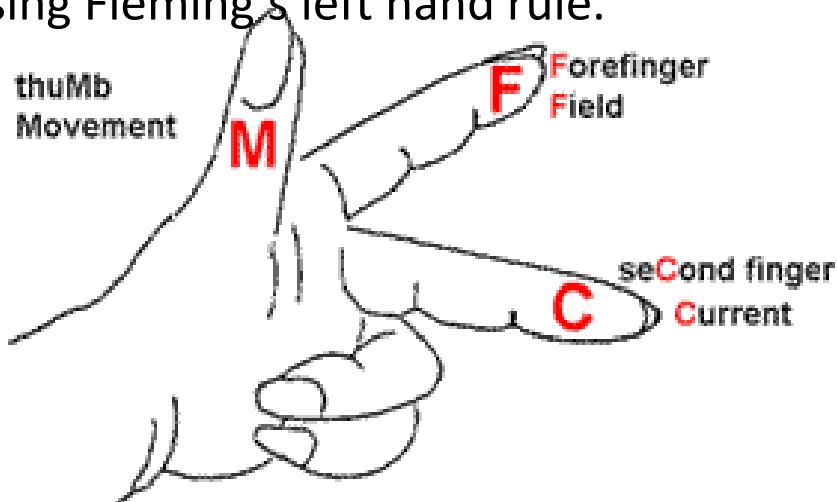Current In

S

The Motor Effect

Electric currents always produce a magnetic field. The magnetic field of a single current carrying wire is like this:

If we put a current carrying wire in a magnetic field, we see that there is a force.

Wire carrying current I

Direction **(movement)** of the force can be found using Fleming's left hand rule.

thuMb
Movement

M

F Forefinger
Field

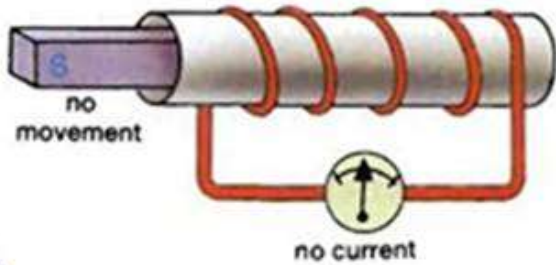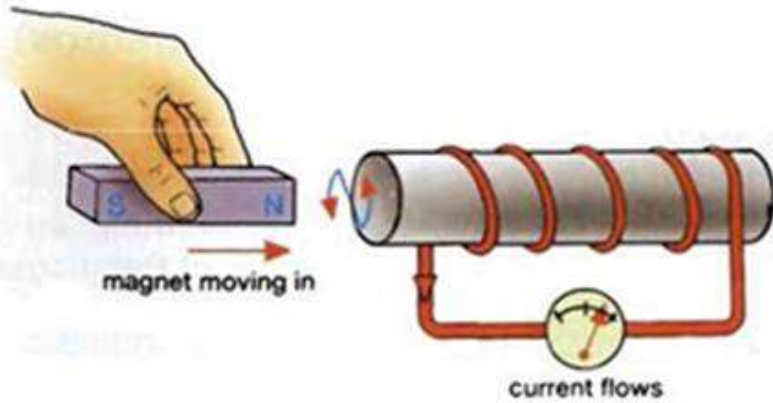seCond finger
C Current

Fleming's Left Hand Motor Rule

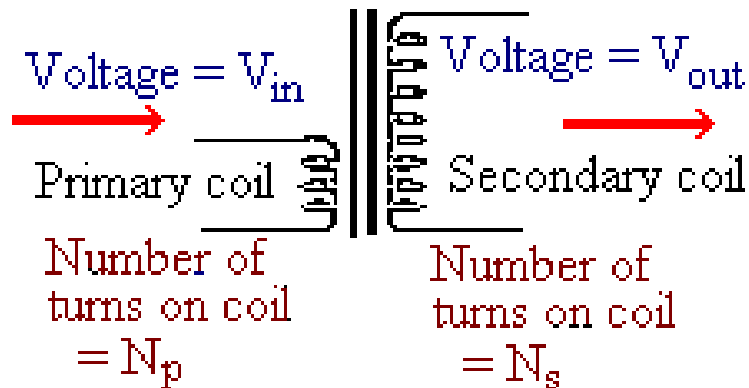N   S

Direction of force, F

The size of the force can be increased by:
❑ Increasing the strength of the magnetic field
❑ Increasing the size of the current

Electromagnetic induction

magnet moving in

current flows

no movement

no current

moving out

current flows opposite way

Transformers

Voltage = V_{in}

Primary coil

Number of turns on coil = N_p

Voltage = V_{out}

Secondary coil
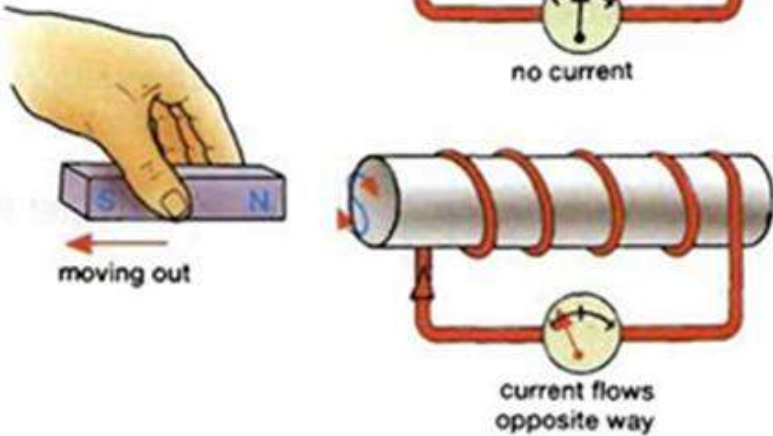
Number of turns on coil = N_s

If N_s is more than N_p, we have a "Step-Up" transformer

If N_s is less than N_p, we have a "Step-Down" transformer

All of these questions can be done using $\dfrac{V_{in}}{V_{out}} = \dfrac{N_p}{N_s}$

P1.26 Generating Electricity

A Generator
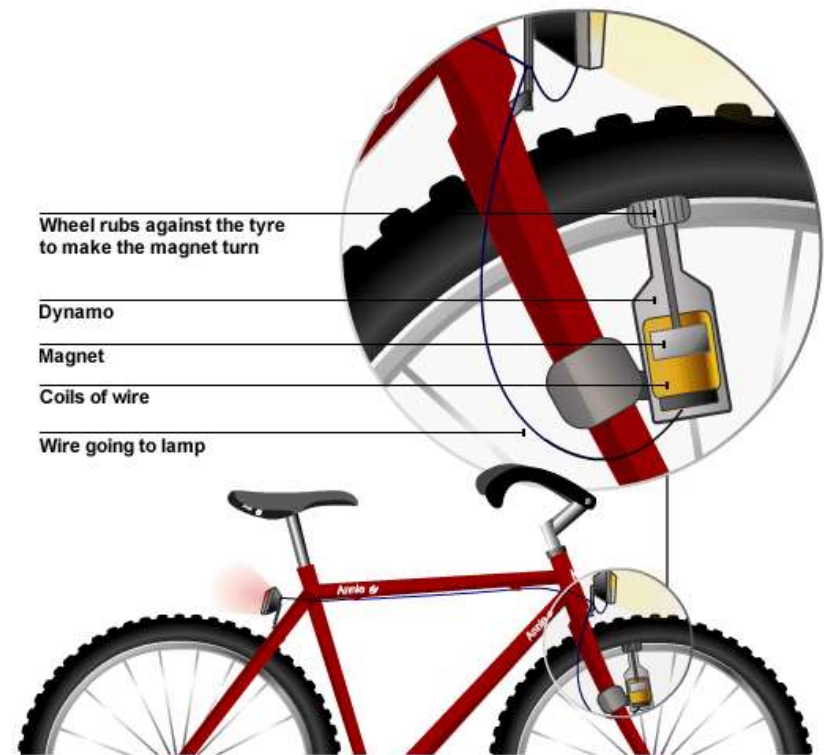
- Current is induced in the coil. And transferred to a circuit through the slip rings which touch carbon brushes.

- As the coil turns the direction of the induced current changes.

- Alternating Current (A.C.) is induced
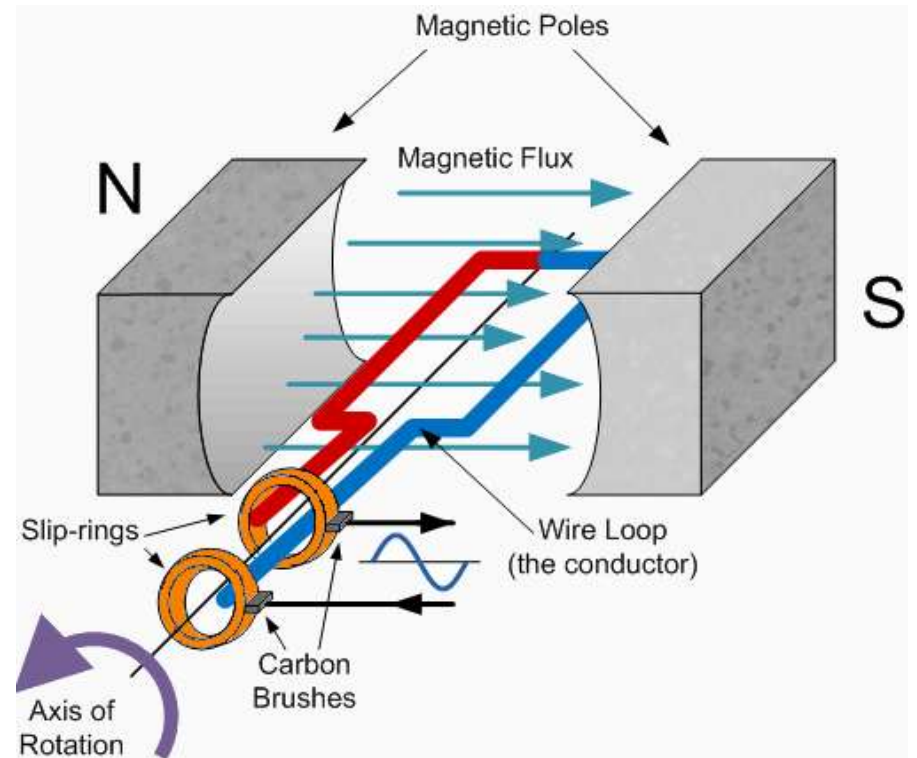
P1.26 Generating Electricity

A Dynamo

- Used to produce electricity to power cycle lights.
- Magnet spins inside a coil of wire
- A current is induced.
- Direct current (D.C)
- Other examples are wind up torches or radios.

Wheel rubs against the tyre to make the magnet turn

Dynamo

Magnet

Coils of wire

Wire going to lamp

P1.27 Transmitting Electricity

Key words:

- Transformers – change the size of an alternating voltage.

- Step up transformer – increases the voltage

- Step down transformer – decreases the voltage

Electricity is transmitted at high voltages as it increases efficiency by reducing heat loss in the power lines.
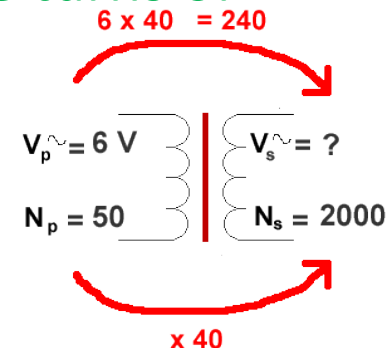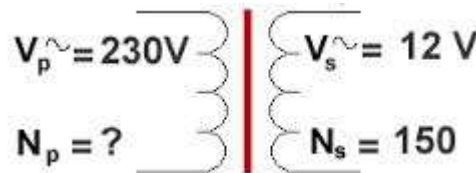
P1.27 Transmitting Electricity

- A transformer consists of two coils wrapped around an iron core.
- Electricity is supplied to the primary coil and obtained in the secondary coil at a different voltage.
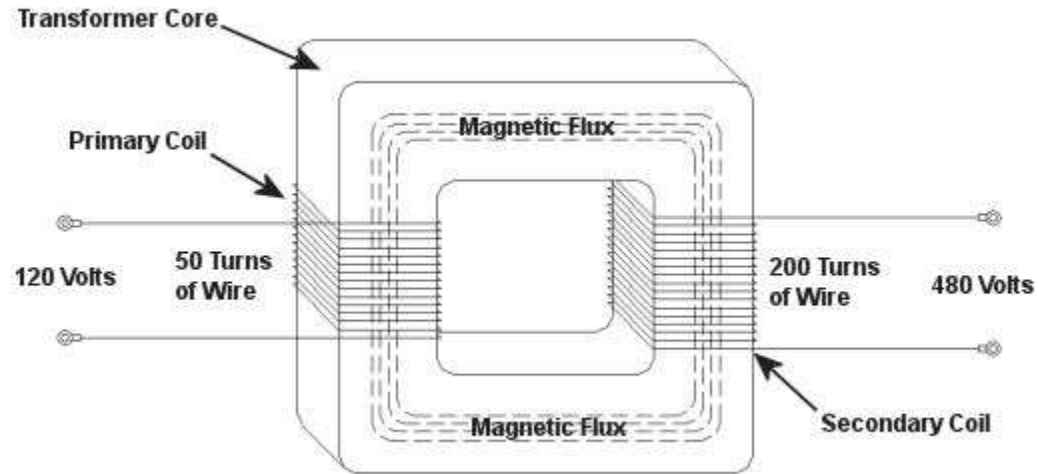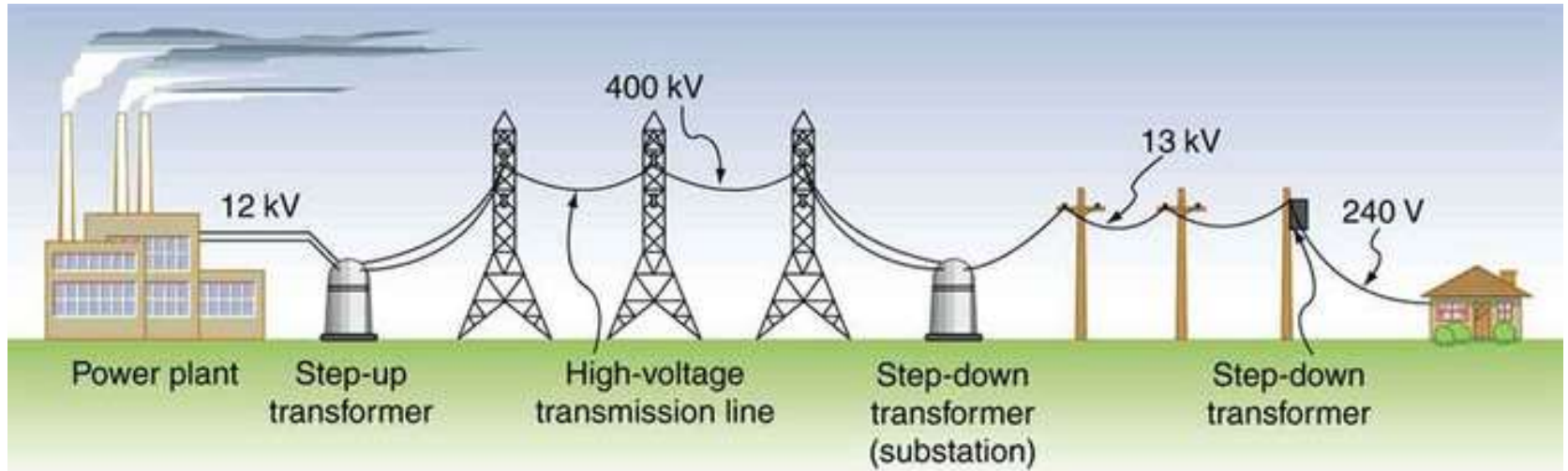

$$\frac{\text{Voltage in Secondary Coil}}{\text{Voltage in Primary Coil}} = \frac{\text{Turns on Secondary Coil}}{\text{Turns on Primary Coil}}$$

You need to be able to use this formula to work out the turns of the voltage:

Try these examples…

$V_p^{\sim} = 230V$ $V_s^{\sim} = 12\ V$

$N_p = ?$ $N_s = 150$

$6 \times 40\ = 240$

$V_p^{\sim} = 6\ V$ $V_s^{\sim} = ?$

$N_p = 50$ $N_s = 2000$

$\times 40$

P1.27 Transmitting Electricity

Voltage increased to 400,000V to reduce heat loss

Voltage reduced to 33,000V for factories

Voltage reduced to 230/240V for homes

Hazards of electrical transmission
- High voltages are likely to kill.