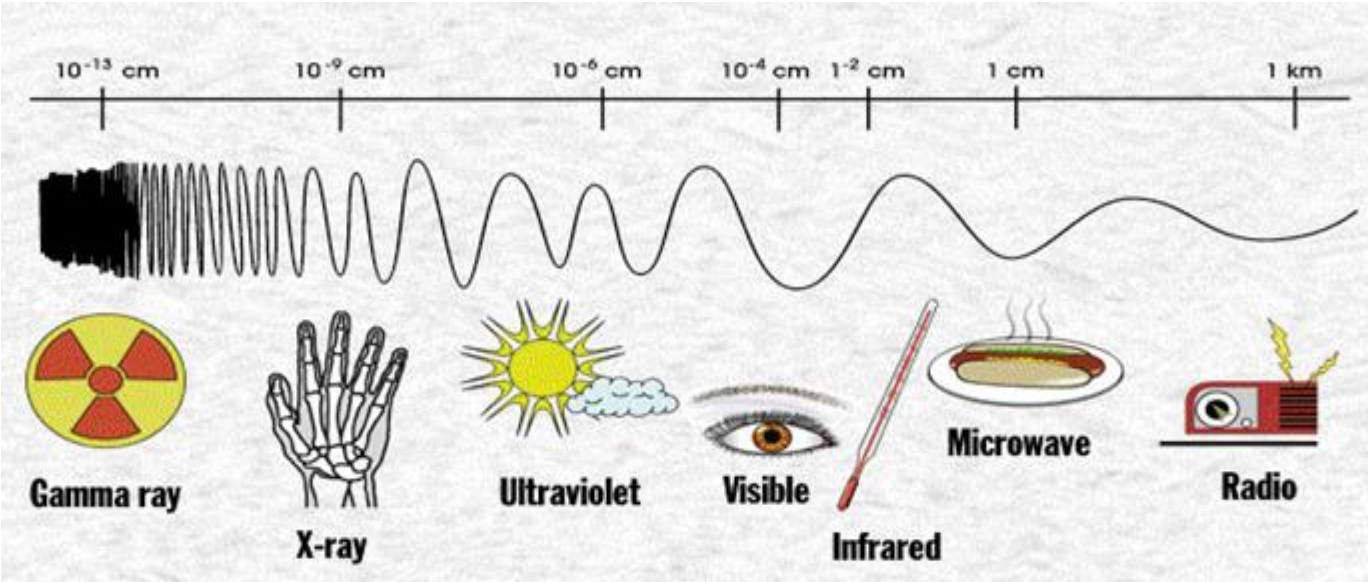
Physics Unit 3 Revision (Higher tier)

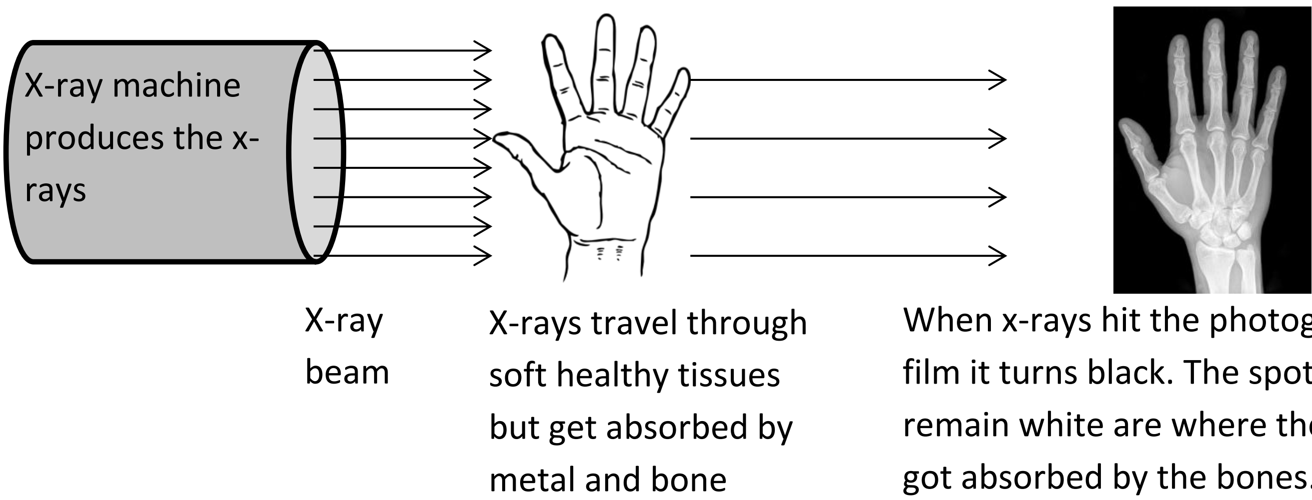
X-rays

X-rays are part of the electromagnetic spectrum, between gamma rays and UV

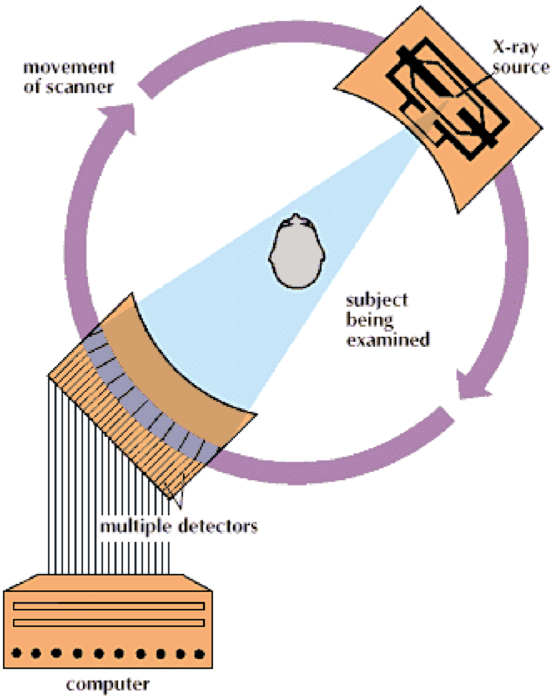


X-rays have a short wavelength (about the diameter of an atom) and can cause ionisation. Ionisation is when the x-rays cause atoms to lose electrons, so when an x-ray hits and electron orbiting a nucleus it gives it enough energy to become free from the atom.

X-rays are used for medical imaging, in particular for imaging bones.



X-rays images can be recorded on photographic film or digitally (details below). X-rays aren't suitable for pregnancy scans are the radiation can cause mutations to the baby which could cause abnormal growth or birth defects.



<u>**CT scanner**</u>

Another type of x-ray machine is a Computerised Tomography scanner **or CT scanner**. This type of x-ray machine rotates around your body in order to build up a 3D image of the body.

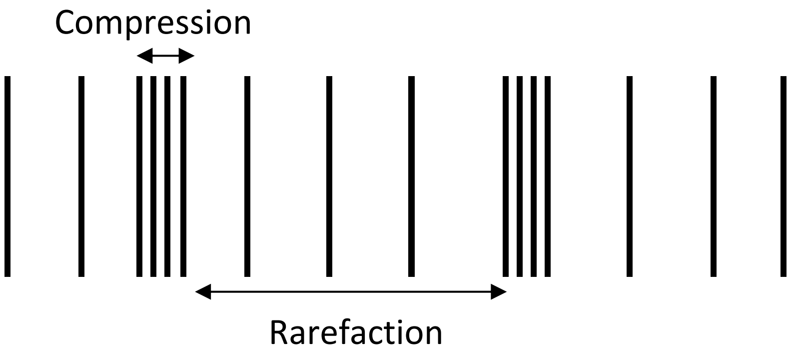
The images from a CT scanner are formed electronically by using a **CCD (Charged Coupled Device)** instead of photographic film. These CCDs allow the images to be recorded digitally, just like a digital camera.

X-rays and CT scanners can be used to diagnose medical condition such as bone fractures/breaks and dental problems. They can also be used to treat some medical conditions, for example they can be used to kill cancer cells.

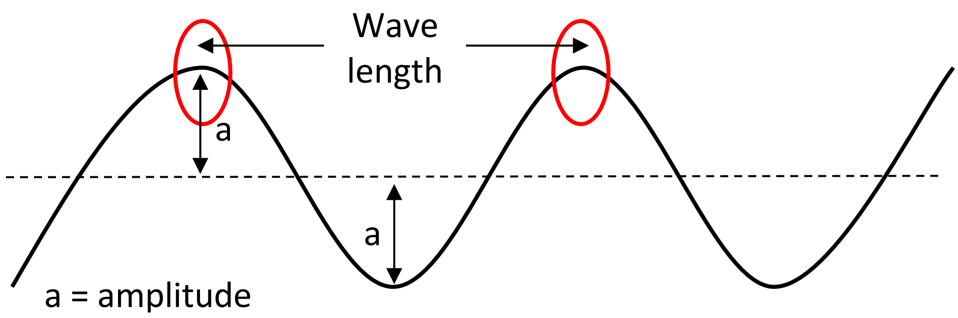
However, as x-rays are ionising, you do need to take precautions when using them otherwise you risk getting cancer. One precaution is that patients are only allowed a certain amount of x-ray scans in a year. The radiographers (the medical staff in hospitals taking the scans) have to be behind safety screens that absorb x-rays to keep them safe. Hospital staff also wears special badges that change colour if they have been exposed to a high dose of x-rays.

Ultrasound

Sound is a **longitudinal** wave and travels by particles vibrating (mechanical vibrations. Sound can not travel in a vacuum (empty space) because there are no particles to carry the sound. Sound will travel faster in denser materials e.g. faster in metal than air. Sound travels at about 340 m/s in air.



Longitudinal waves oscillate parallel to the direction of travel e.g. sound waves



Transverse waves oscillate perpendicular (right angles) to the direction of travel e.g. light waves

The frequency is the number of waves that occur every second. The frequency is measured in Hertz (Hz). In the case of sound, the frequency determines the pitch – high frequency = high pitch, low frequency = low pitch.

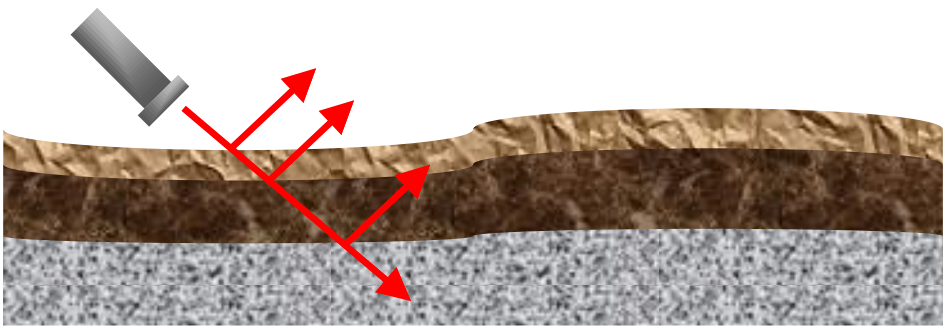
The hearing range for humans is 20Hz to 20 000Hz or 20kHz (kilohertz).

Amplitude is how 'tall the wave is and in the case of sound a large amplitude means a loud sound, a small amplitude means a quite sound.

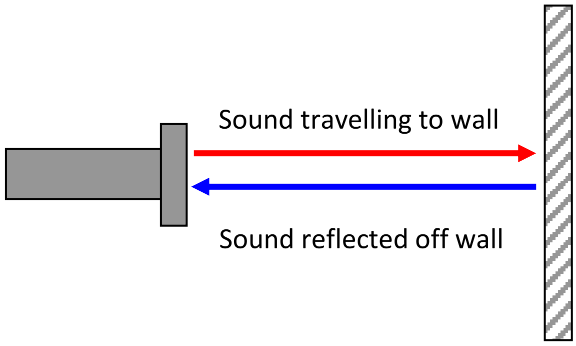
The wavelength the distance between one point on the wave to the next corresponding point, measured in metres (m). The easiest way to think of it is the distance between one peak and the next peak OR one compression to the next compression, this is one complete wave

Like light waves, sound can be reflected (an echo) and refracted.

Sounds beyond the human hearing range i.e. frequency over 20 000 Hz, are called ultrasounds. Certain animals can hear and produce ultra sounds but humans use electronic devices to produce ultra sounds.



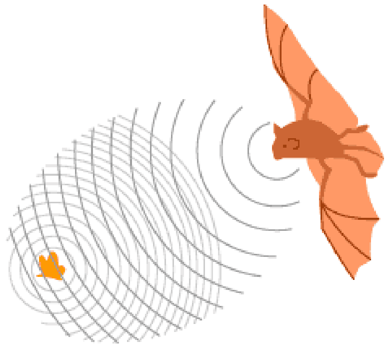
Ultra sounds get partially reflected when they meet a boundary between two different mediums.



An ultra sound pulse needs to travel to the medium and back to the detector. So if a detector indicated that the ultra sound took 10 seconds to return. This must mean that the object is 5 seconds away. If we know how fast the ultra sound is travelling then we can work out how far away it is.

Example question:

If it took 1 second for a bat to detect the ultrasound, how far away is the prey? Sound travels at 340 m/s

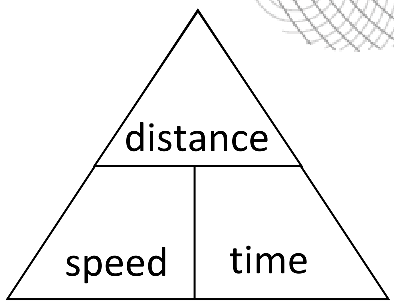


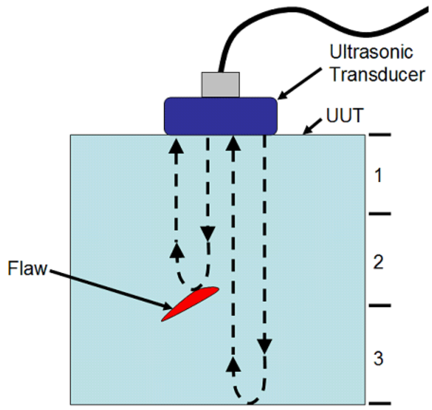
Bat detected ultrasound after 1 second

Therefore the prey is 0.5 seconds away

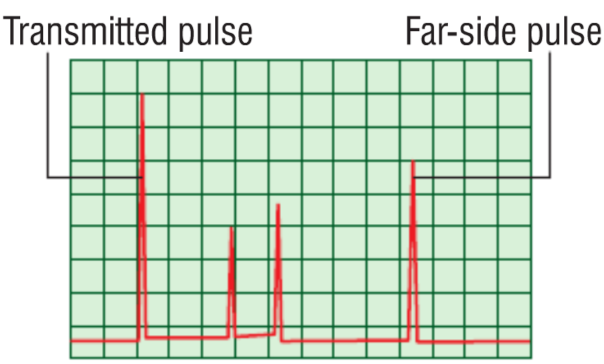
Distance = speed x time

Distance = 340 x 0.5 = 170m





Ultrasounds have several uses including medical scans and procedures (e.g. pre natal scans, breaking up kidney stones), detecting flaws in materials (e.g. crakes in pipes) and cleaning devices (e.g. breaking up trapped dirt in watches).



The oscilloscope trace to the left shows the ultrasound pulses detected in a metal. The transmitted pulse was when the ultra sound was sent into the metal and the far side pulse is when it returned. However, you can see 2 other peaks (or pulses) in between the transmitted and far side pulse. These pulses show where the wave was reflected – this must mean that there are 2 flaws in the metal. If one horizontal square represents 1 second then the first flaw is showing up after 3s (3 squares) after the transmitted pulse. Remember though, the sound travels there and back before it turns up on the oscilloscope. This means that the ultrasound reached the flaw after 1.5 seconds (half of 3 seconds).

X- Rays	CT Scanners	Ultrasound
High radiation dose – can cause cancer	Highest radiation does – can cause cancer	No radiation – no cancer caused
Ionising	Ionising	Non – ionising
Medium image quality – doesn't distinguish between types of soft tissues	Good image quality – can distinguish between types of soft tissues – produces a 3D image	Bad images quality – only one that is suitable for baby scans as it is non-ionising (no radiation)

Sample Question 1

1 (a) This information is from a science magazine.

> Electronic systems can be used to produce ultrasonic waves.
> These waves have a frequency higher than the upper limit for hearing in humans.

Complete the sentence by choosing the correct number from the box.

20	**2000**	**20 000**	**200 000**

The upper limit for hearing in humans is a frequency of .... Hz.

(1 mark)

1 (b) An electronic system produces ultrasound with a frequency of 500 kHz.

What does the symbol kHz stand for?

....

(1 mark)

1 (c) (i) State **one** industrial use for ultrasound.

....

(1 mark)

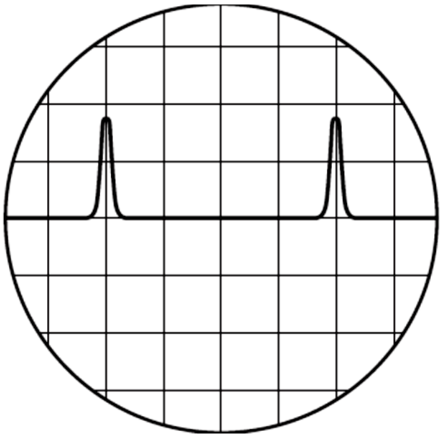
1 (c) (ii) State **one** medical use for ultrasound.

....

(1 mark)

1 (d) An ultrasound detector is connected to an oscilloscope.

The diagram shows centimetre squares on an oscilloscope screen.
Each horizontal division represents 2 microseconds.



Calculate the time, in microseconds, between one peak of one ultrasound pulse and the peak of the next.

....

Time = ... microseconds

(1 mark)

1 (e) Ultrasounds are partially reflected when they reach a boundary between two different media.
The time taken for the reflection from the boundary to reach the detector can be seen from the screen.
What can be calculated from this time interval?

....

....

(2 marks)

1 (f) Explain what action scientists should take if they find evidence that ultrasonic waves may be harmful to human health.

....

....

....

(2 marks)

Sample Question 2

(a) After a person is injured a doctor will sometimes ask for a photograph to be taken of the patient's bone structure, e.g. in the case of a suspected broken arm.

(i) Which type of electromagnetic radiation would be used to take the photograph?

....

(1)

(ii) Describe the properties of this radiation which enable it to be used to photograph bone structure.

....

....

....

....

(2)

(b) Explain fully why pregnant women should not normally have X-rays of the lower body.

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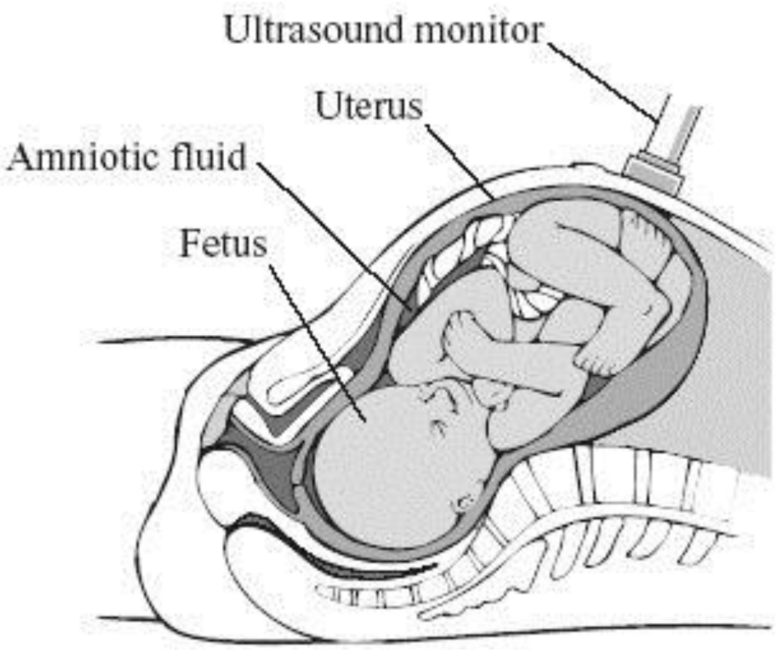
(4)

(Total 7 marks)

Sample Question 3

The diagram shows an ultrasound monitor being used to scan a fetus.



The table shows the velocity of ultrasound waves in different tissues of the fetus.

Tissue	Velocity of ultrasound in m/s
Amniotic fluid (liquid surrounding fetus)	1540
Bone	3080
Kidney	1561
Liver	1549
Muscle	1585

Explain why we are able to see the different parts of the fetus in an ultrasound scan. You may use information from the table in your answer.

To gain full marks in this question you should write your ideas in good English. Put them into a sensible order and use the correct scientific words.

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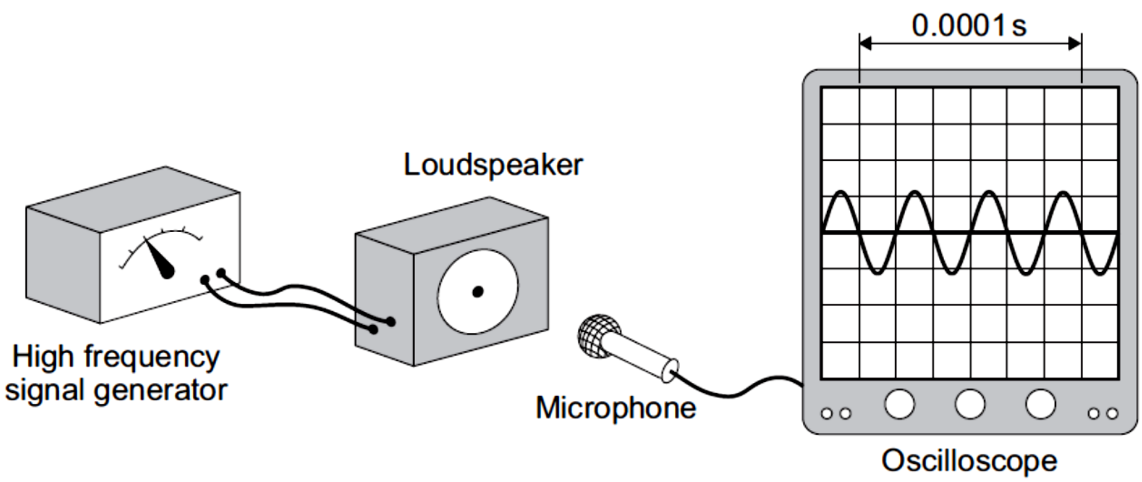
(Total 4 marks)

Sample Question 4

5 (a) The diagram shows a microphone being used to detect the output from a loudspeaker. The oscilloscope trace shows the wave pattern produced by the loudspeaker.



5 (a) (i) How many waves are produced by the loudspeaker in 0.0001 seconds?

....

(1 mark)

5 (a) (ii) How many waves are produced by the loudspeaker every second?
Assume the input to the loudspeaker does not change.

....

....

(1 mark)

5 (a) (iii) A person with normal hearing cannot hear the sound produced by the loudspeaker.
Explain why.

....

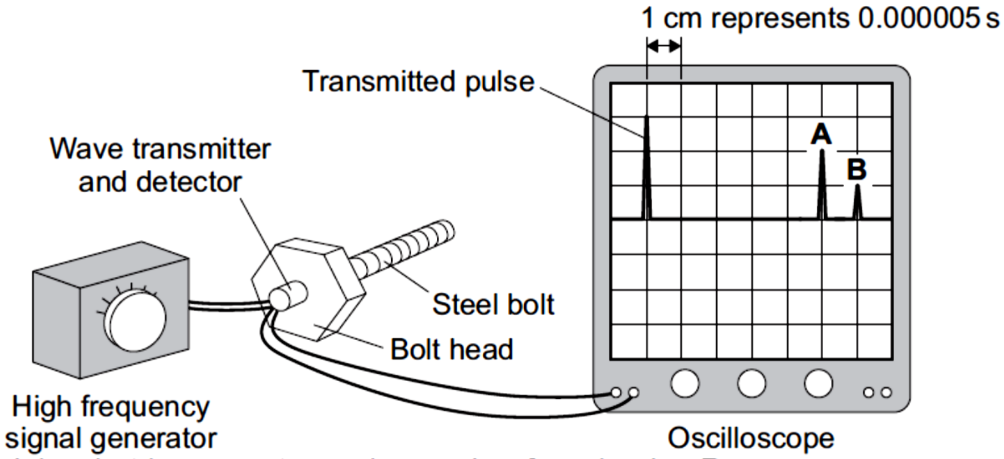
....

....

....

(2 marks)

5 (b) The diagram shows how a very high frequency sound wave can be used to check for internal cracks in a large steel bolt. The oscilloscope trace shows that the bolt does have an internal crack.



5 (b) (i) Explain what happens to produce pulse **A** and pulse **B**.

....

....

....

....

(2 marks)

5 (b) (ii) Use the information in the diagram and the equation in the box to calculate the distance from the head of the bolt to the internal crack.

distance = speed × time

Speed of sound through steel = 6000 m/s
Show clearly how you work out your answer.

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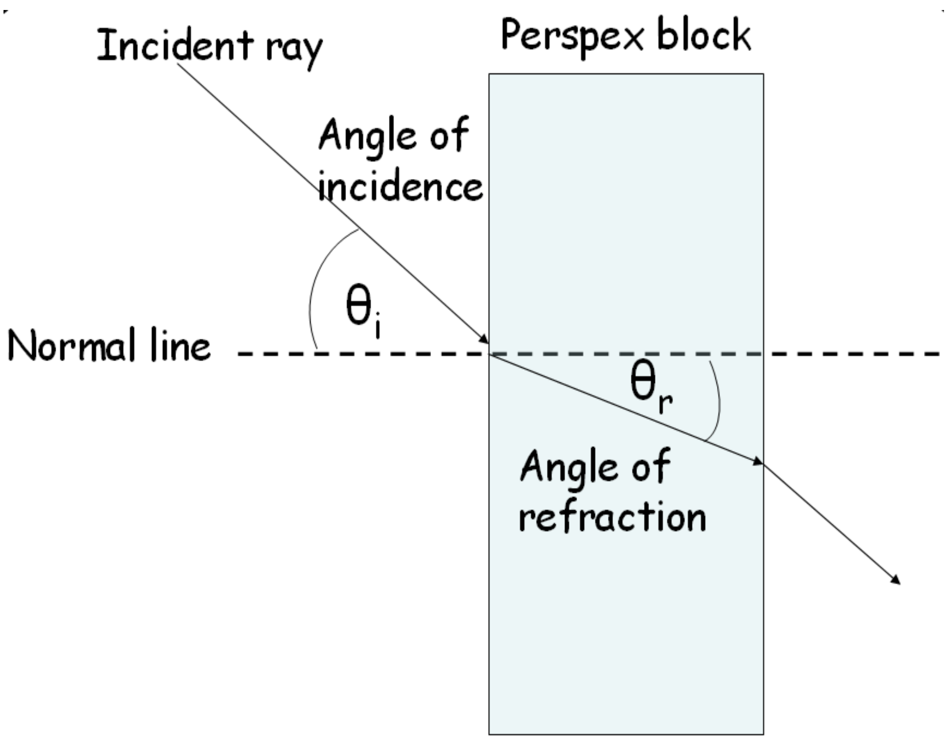
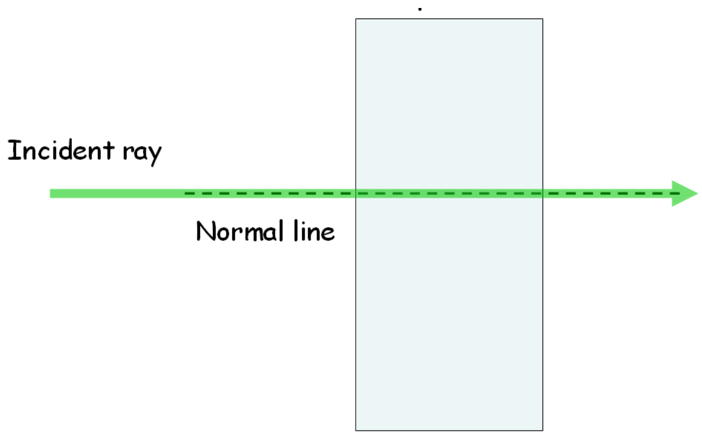
....
(3 marks)

Refraction and lens

Refraction is when a wave changed direction when entering a more/less dense medium.



Using the example of light, when the ray enters the Perspex block from air it gets slowed down as Perspex is denser. This also causes the ray to change direction (bends towards normal). When the light is leaving the block it speeds up as air is less dense than Perspex. The ray will then bend away from the normal line.



If the light enters along the normal line i.e. perpendicular to the surface of the material then no refraction occurs. The light will still be slowed down as it is travelling through a denser material but the light will not change direction.

Different materials will cause light to get refracted by different amounts (as they will have different densities). The ***refractive index*** is a number that tells us how much refraction will occur for different material, the bigger the refractive index then the bigger the refraction. For example, the refractive index of glass is 1.5 and the refractive index for diamond is 2.4. This means diamond will refractive (bend) light more than glass as it has a bigger refractive index.

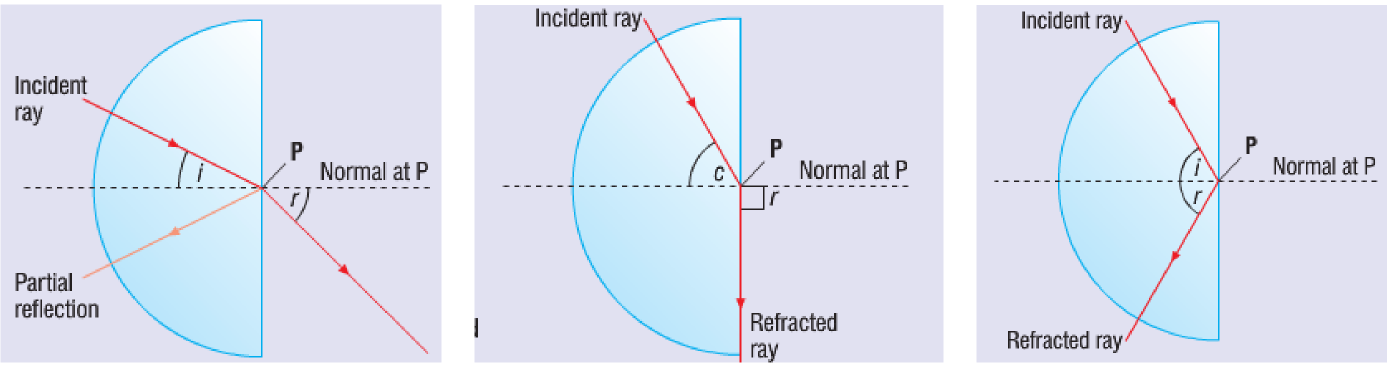
The refractive index is calculated using the following equation (known as Snell's Law):

$$refractive\ index = \frac{\sin i}{\sin r}$$

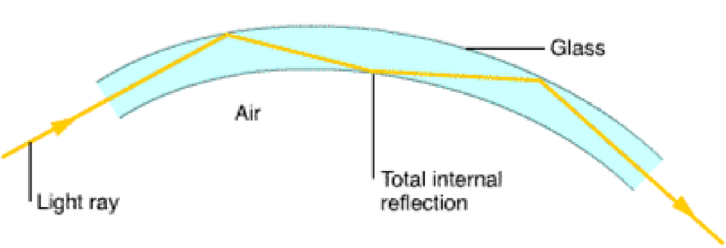
i = angle of incidence

r = angle of refraction

Refraction can also cause an effect called **total internal reflection**. The diagram below shows this effect.



This is when light is traveling from a more dense medium to a less dense medium (e.g. from Perspex to air). When the angle of incidence gets



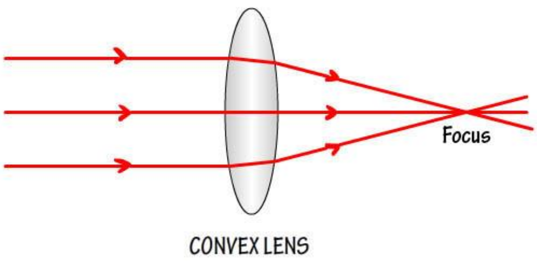
increased to a certain amount the light will not leave the block, it will travel along the boundary between both mediums (centre diagram). This angle, labeled c, is the **critical angle**. If the angle of incidence is then further increased total internal reflection can occur; this is when the light gets reflected within the medium (e.g. in the right diagram above the medium is the semicircular block). Total internal reflection happens in optical fibres which are used in **endoscopes** to view the inside of your bodies.

Laser light is sometimes used in optical fibres and endoscopes too. It is used in medicine for cutting tissue, sealing off leaking blood vessels (cauterizing), eye surgery etc.

If you know the critical angle, then the refractive index can be calculated by using

$$Refractive\ index = \frac{1}{\sin c}$$

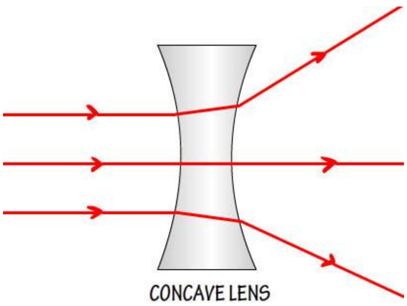
Lenses use the effect of refraction to form images and there are 2 types; Concave, curved inwards or convex, curved outward

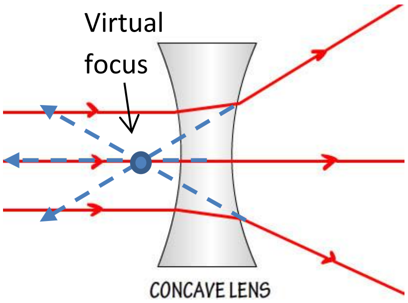


Convex (converging lens)

A converging lens focuses parallel light to one point i.e. converges the light.

The point where the light gets focused is called the focal point.



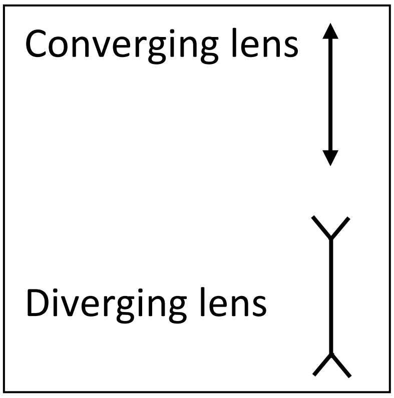


Concave (diverging lens)

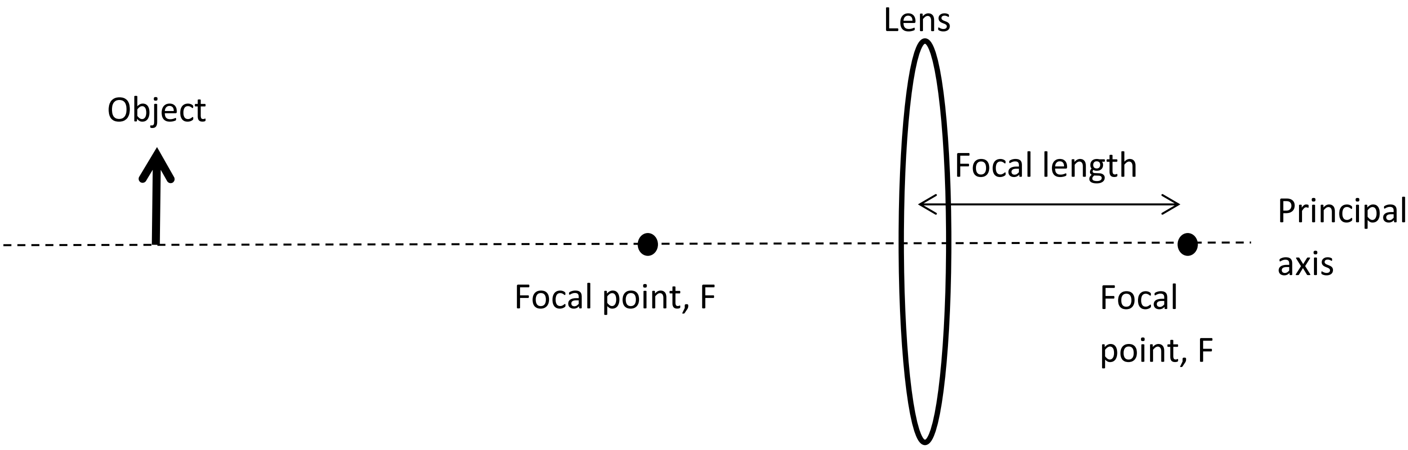
A diverging lens makes the parallel light spread out i.e. diverges the light

As a concave lens cause the light to spread out, this means that they will never all meet at one *real* focal point. But if we draw lines going straight back from the diverged rays we can see that these *imaginary* rays do all cross at a point. This is called the *virtual focus*. This is the point that light appears to be focused at

On a ray diagram a converging lens is often shown as an arrow shown as a double headed arrow (see right). A diverging lens is diverging lens is represented as shown in the diagram



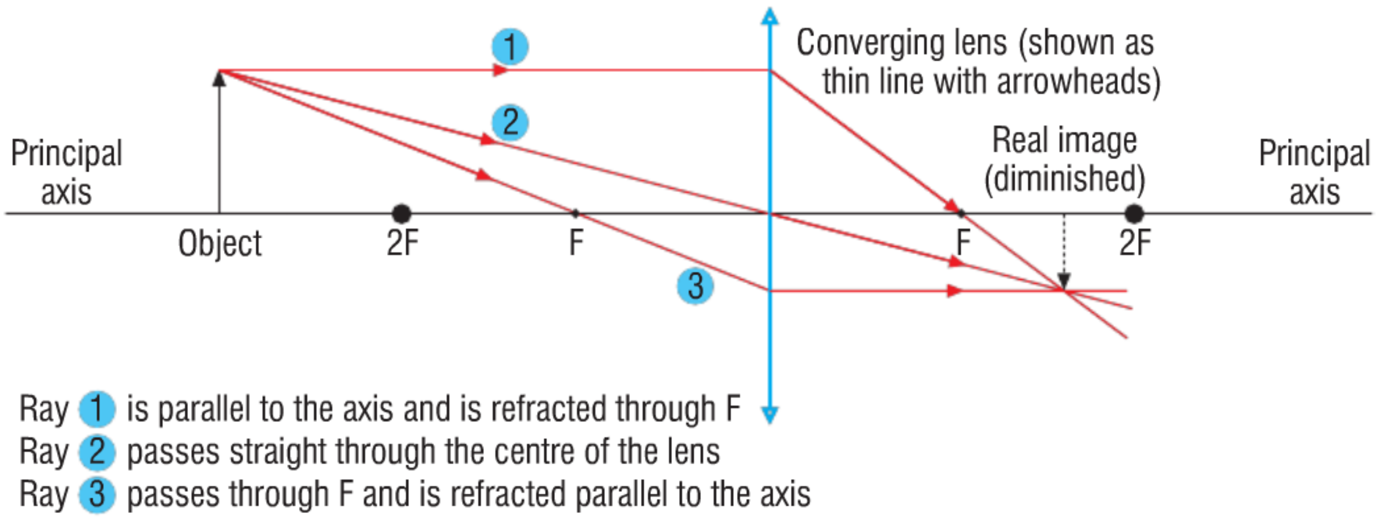
When we draw ray diagrams for a lens we begin by drawing a horizontal line called the ***optical or principal axis*** and our lens is half way down that line. The object that the lens is focusing on sits on the principal axis. The object (e.g. lamp, person, car, anything) is represented by an arrow. The focal point of the lens is called F. The distance between the lens and the focus is called the ***focal length***



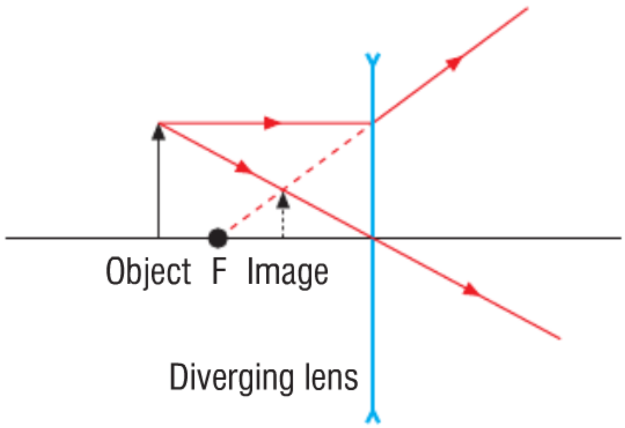
To find out where an image is formed by a lens we draw a ray diagram. This is best achieved by drawing two rays of light;

- 1st ray is from the top of the object to the lens (parallel to principal axis). When the ray reaches the lens it gets refracted through the focus
- 2nd ray is from the top of the object straight through the centre of the lens.

Where these 2 rays cross is the top of the image. An optional 3rd ray can be drawn but it is not necessary.



A concave lens ray diagram is very similar to a convex one. Draw 2 rays.



- One from the top of the object to the lens (parallel to the principal axis). Then from the lens diverging outwards ensuring you use the focal point to guide your ray.
- 2nd ray from top of the object straight through the centre of the lens.

Where your lines cross is where your image is formed. The image formed is called a ***virtual image*** as it is not formed by the actual light rays. We use have used imaginary rays, where the light appear to be coming from. **USES**: Spectacles for short sightedness (Myopia) and door peep holes.

A Virtual image is one that is not made from real light rays. Virtual images cannot be projected onto a screen.

A real image is made from real light rays which can be focused to appear onto a screen e.g. a movie projector

Images **must** be described by 3 key points:

1. image size compared to object size i.e. is image bigger or smaller
2. is image upright or inverted (upside down) compared to object
3. is image real or virtual (made from real light rays or imaginary light rays)

Diverging lenses always produce the same type of image:

1. Virtual
2. upright
3. smaller

Some can images are bigger or smaller that the object. In order to work out the amount of magnification we use this formula:

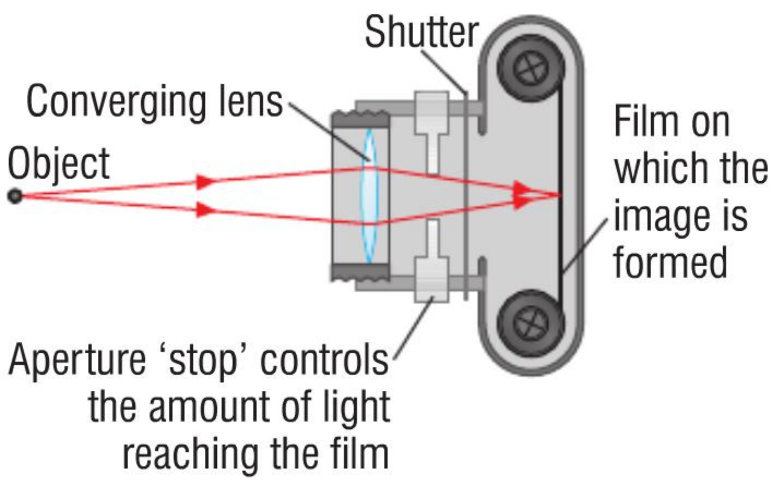
$$magnification = \frac{image\ height}{object\ \ height}$$

If the magnification is less than 1 then the image is smaller than the object.

If the magnification is more than 1 then the image is bigger than the object.

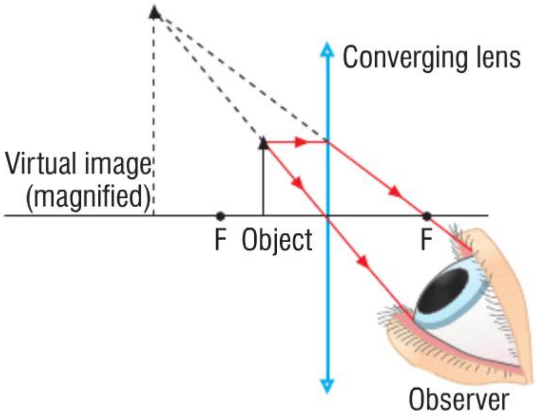
If the magnification is equal to 1 then the image and object are the same height.

Converging lenses can produce different images depending on where they are placed. If you refer to the diagram on page 14 (previous page) you will notice that the principal focus (F) is labelled and another point 2F – this point is twice the focal distance away from the lens. If an object is placed outside 2F then the image produced is Real, diminished and inverted. This type of lens is in your eye to focus the image on your retina (the light sensitive cells). It is also used in cameras to focus the image on the back of the film (or CCDs in digital cameras).



If an object is placed between 2F and F then the image produced will be real, inverted and magnified. A use for this is in projectors.

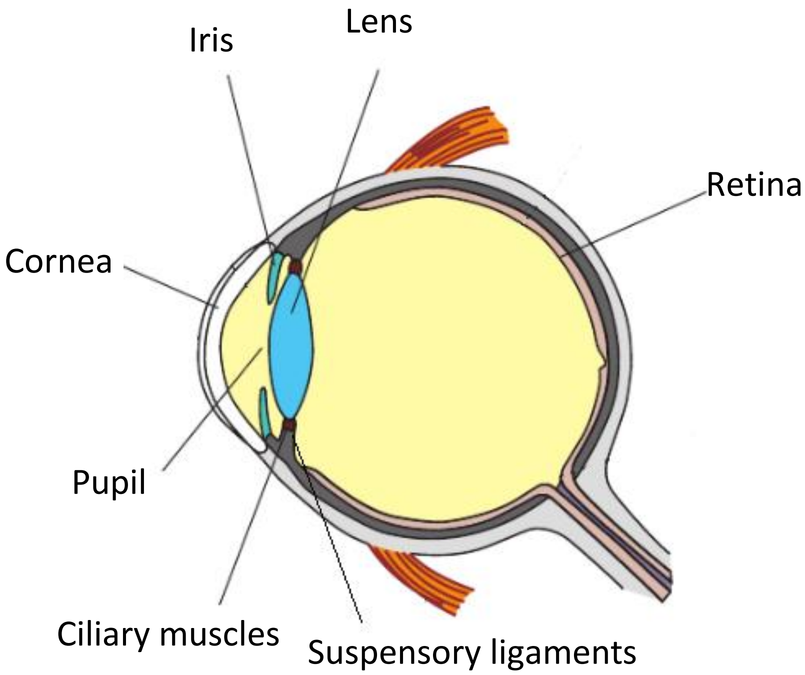
If an object is placed at F then the rays of light will never meet. This is used for spotlights.



If an object is placed between the principal focus (F) and the lens then a virtual image can be produced (see diagram). This image is upright and magnified and a use for this is magnifying glasses.

The eye

You eye has several different parts to it, each with a specific job

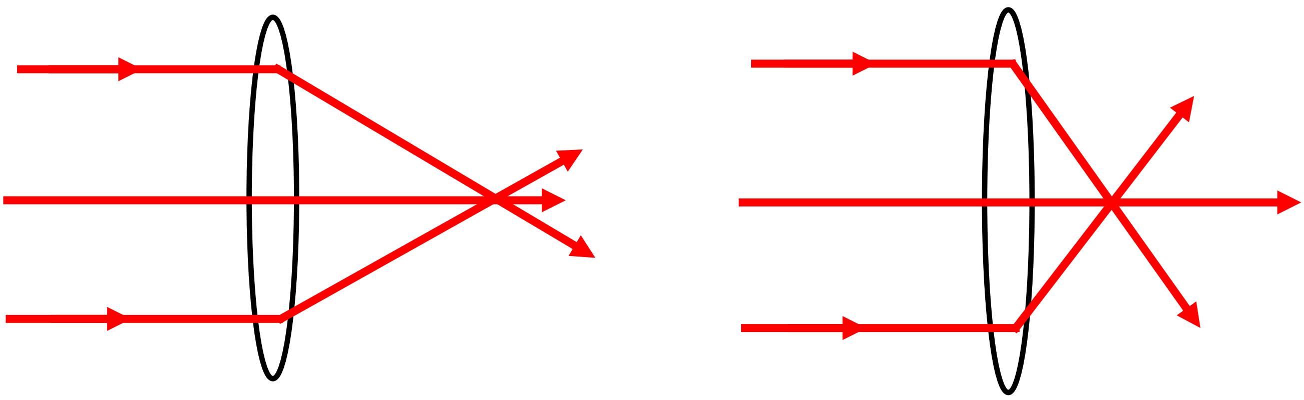


Retina	The light sensitive cells around the eye
Eye Lenses	Focuses light onto the retina
Cornea	Transparent layer that protects the eye and helps to focus light onto the retina
Pupil	The central hole formed by the iris. Light enters the eye through the pupil
Iris	Coloured ring of muscle that controls the amount of light entering the eye
Ciliary muscle	Attached to the suspensory ligaments. The muscles change the thickness of the eye lens
Suspensory ligaments	Connects the ciliary muscle to the lens

You eye has a huge range of vision being able to focus things close up (**<u>near point which is about 25cm</u>**) and far away (**<u>far point is infinity</u>**). It can do this because the ciliary muscles can change the shape of your lens which will change your focal length. The roles of the eye and the camera can be compared

	The eye	**The camera**
Type of lens	Variable focus converging lens	Fixed focus converging lens
Focusing adjustment	Ciliary muscle alters the lens thickness	Adjustment of lens position
Image	Real, inverted, magnification less than 1	
Image detection	Light sensitive cells on the retina	Photographic film (or CCD sensors in a digital camera)
Brightness control	Iris controls the width of the eye pupil	Adjustment of aperture 'stop'

The power of a lens is how well it can cause the rays of light to converge. If they converge very close to the lens then the lens if more powerful. In the diagram below, the lens on the right is more powerful.



Power is measured in diopters (D) and is calculated using the formula

$$Power = \frac{1}{focal\ length\ (in\ metres)}$$

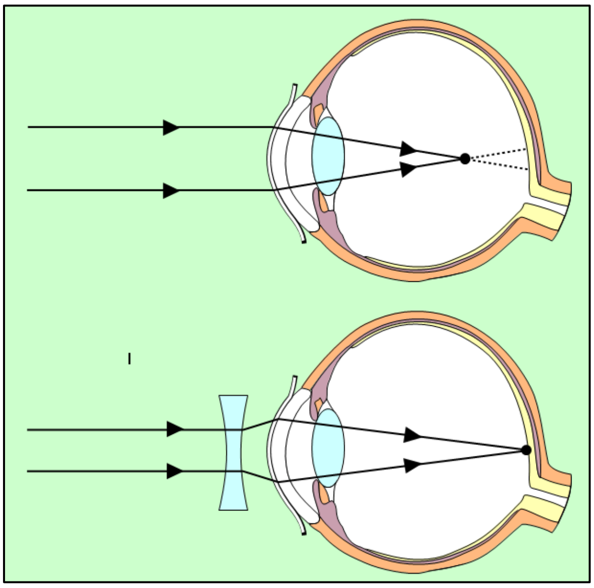
- For converging lens, power has to be given a positive
  - E.g. +5.0D for a focal length of 0.2 m
- For diverging lens, power has to be given a negative value
  - E.g. -2.0D for a focal length of 0.5m

The focal length of a lens depends on 2 factors

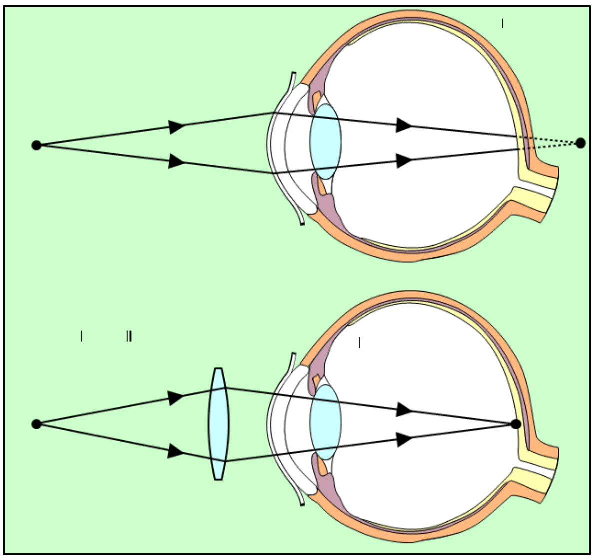
- The refractive index of the lens material (bigger refractive index means shorted focal length which means more powerful)
- How curved the 2 sides of the lens are (the curvature of the lens)
  - If it is less curved (thinner) it will have a bigger focal length (less power) and more curved (thicker) it will have a smaller focal length (more power)

So if you want a really thin lens in a pair of spectacles, then you will need to use a material with a large refractive index

Some people can be shorted sighted (can only focus on things closer up) or long sighted (can only focus on things far away). Short sightedness can occur from the eye ball being too long or the lens being unable to focus. Long sightedness can be caused by the eyeball being too short or the lens being unable to focus.



When a short sighted person tries to focus on an image far away, as demonstrated in the diagram, the light falls short of hitting the retina. This type of person would need a diverging lens to correct their vision. This will help cancel out the excess focusing that is being done by the eye.

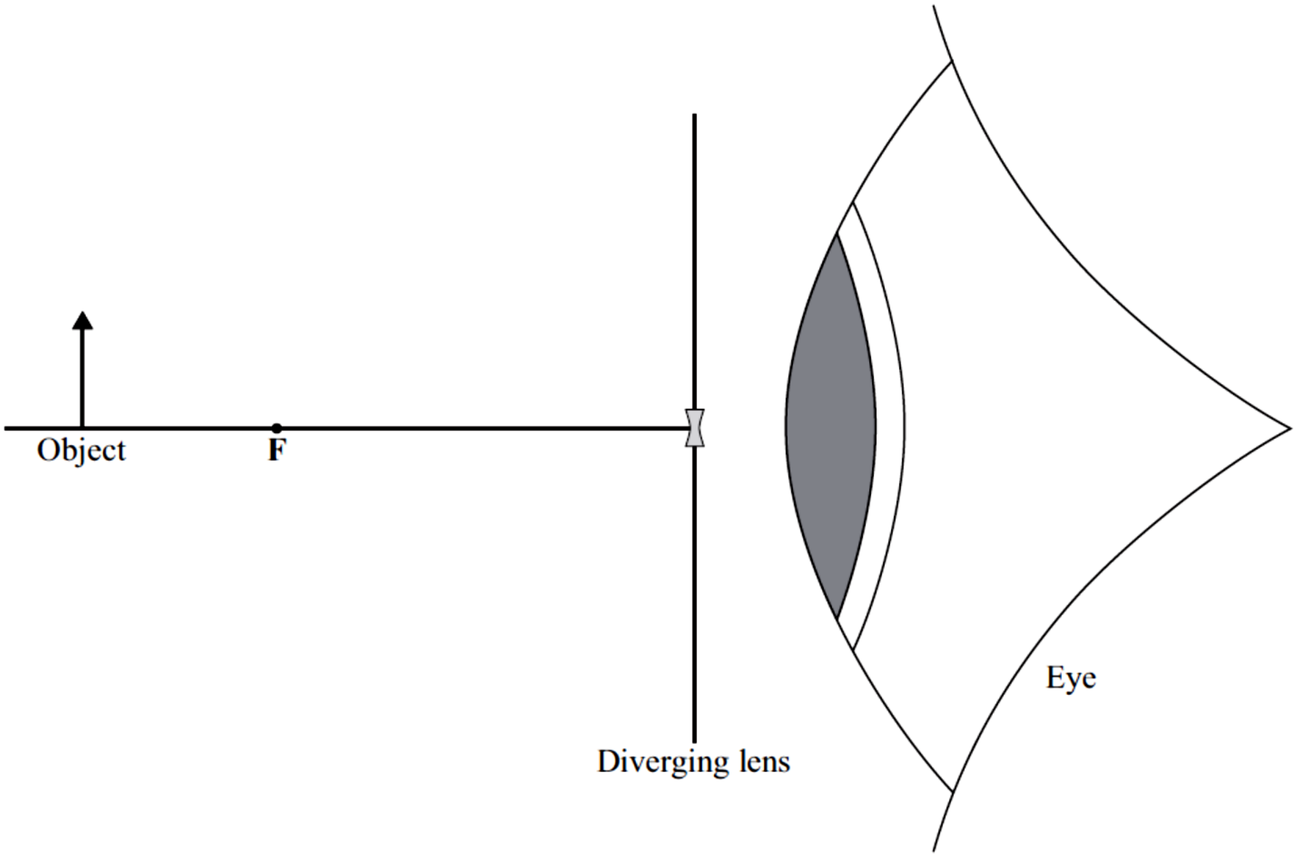


When a long sighted person tries to focus on an image close up, as demonstrated in the diagram, the light doesn't focus soon enough to hitting the retina (it goes too long). This type of person would need a converging lens to correct their vision. This helps as it will start to converge the light earlier and will allow the light to get focused on the retina.

Sample Question 5

4 The diagram shows an object located vertically on the principal axis of a diverging lens. A student looks through the lens and can see an image of the object.

(a) Using a pencil and ruler to draw construction lines on the diagram, show how light from the object enters the student's eye and the size and position of the image.



(3 marks)

(b) Describe the nature of the image by comparing it to the object.

....

....

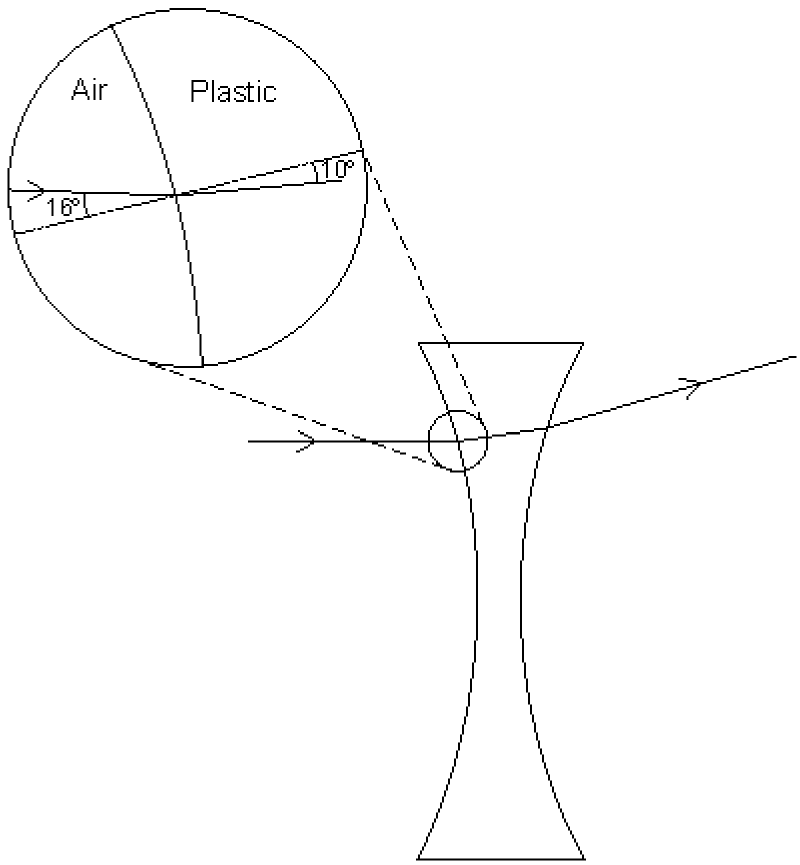
....

....

(2 marks)

Sample Question 6

The diagram shows a ray of light passing through a diverging lens.



(a) Use the information in the diagram to calculate the refractive index of the plastic used to make the lens.

Write down the equation you use, and then show clearly how you work out your answer.

....

....

....

....

....

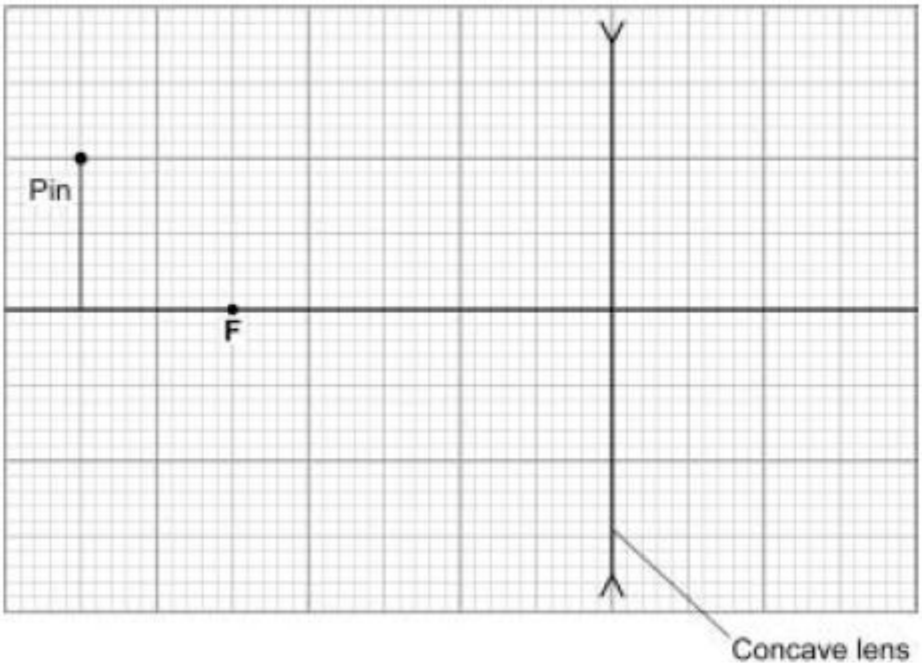
....

Refractive index = ...

(2)

(b) The focal length of the lens is 5 cm. A student looking through the lens sees the image of a pin.

Complete the ray diagram below to show how the image of the pin is formed.



(3)
(Total 5 marks)

<u>Sample Question 7</u>

(a) The diagram shows a lens used as a magnifying glass. The position of the eye is shown and the size and position of an object standing at point **O**.

(i) What type of lens is shown in the diagram?

....

(1)

(ii) Two points are marked as **F**. What are these points?

....

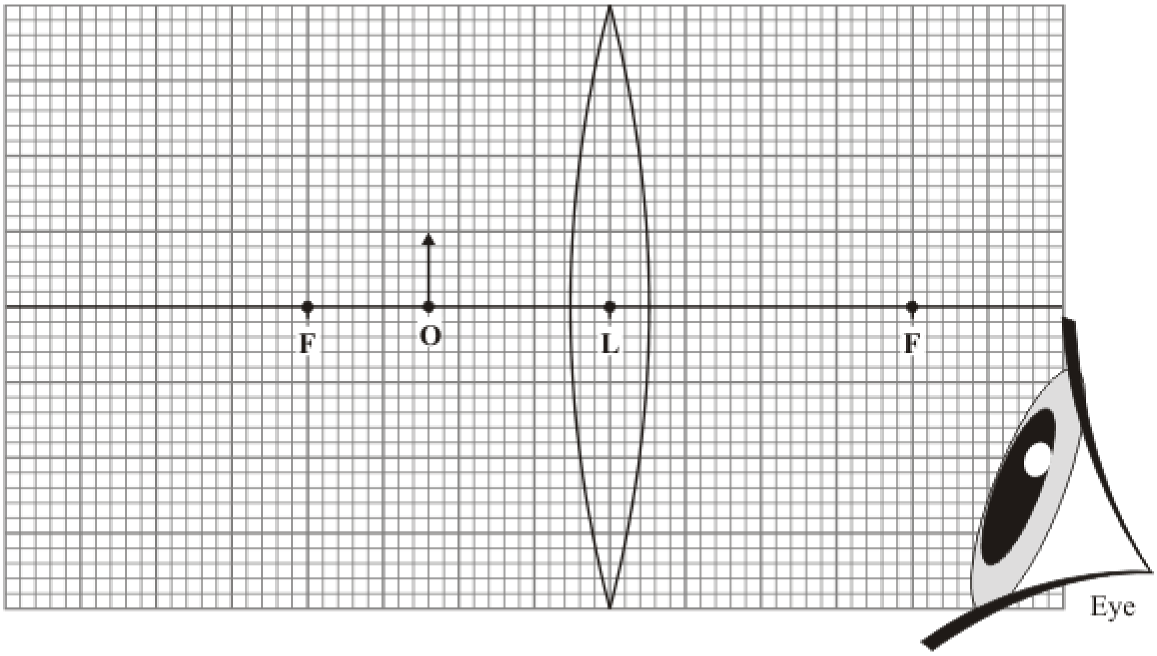
(1)

(iii) What is the name of the straight line which goes through the point **F**, through the point **L** at the centre of the lens, and through the point **F** on the other side?

....

(1)

(iv) On the diagram, use a ruler to construct accurately the position of the image. You should show how you construct your ray diagram and how light appears to come from this image to enter the eye.



(5)

(v) The image is *virtual*. What is a *virtual* image?

....

....

(1)

(b) The lens shown in the diagram in part (a)(iv) can be used in a camera to produce a *real* image.

Explain why a *real* image must be produced in a camera and how the object and the lens are positioned to produce a *real* image which is **smaller** than the object.

Do **not** draw a ray diagram as part of your answer.

....

....

....

....

....

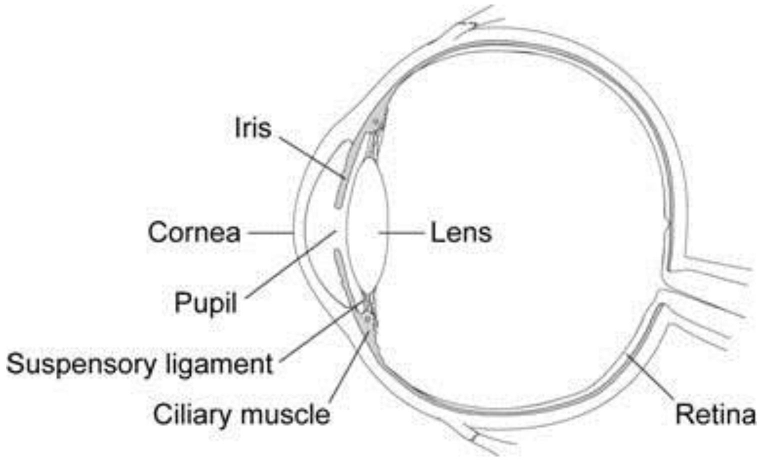
....

(3)

(Total 12 marks)

Sample Question 8

The diagram shows the cross-section of an eye.



(a) Use words from the box to complete each sentence.

ciliary muscle	**cornea**	**iris**	**pupil**

The shape of the lens is changed by the .... ,

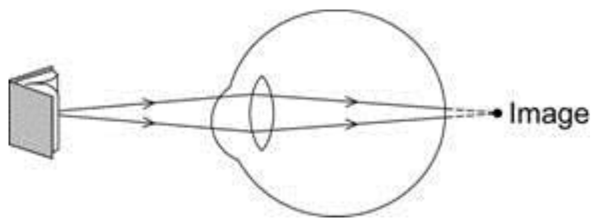
this allows the lens together with the .... to focus light

onto the retina.

(2)

(b) A man, as he gets older, needs to hold a book further from his eyes in order to be able to see the writing clearly.

The diagram shows that his eye lens is not able to focus light on the retina.



(i) How has the 'near point' of the man's eyes changed as he has got older?

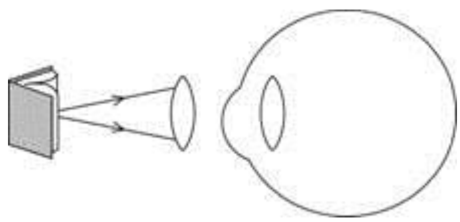
....

....

(1)

(ii) The problem can be solved by wearing reading glasses.

Complete the diagram below to show how the lens below is able to correct the man's vision.



(2)

(c) Give **two** similarities between an eye and a camera.

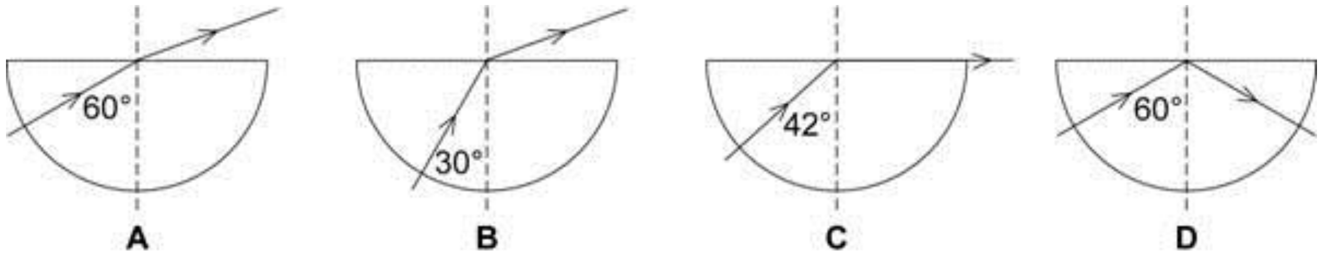
1 ....

2 ....

(2)
(Total 7 marks)

Sample Question 9

(a) Each diagram shows a light ray incident on a glass-air boundary. The critical angle for glass is 42°

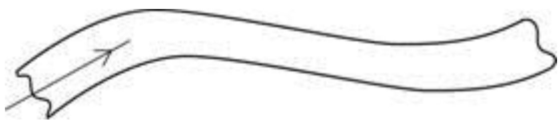


Which **one** of the diagrams, **A**, **B**, **C** or **D**, shows total internal reflection?

Write the correct letter in the box. ☐

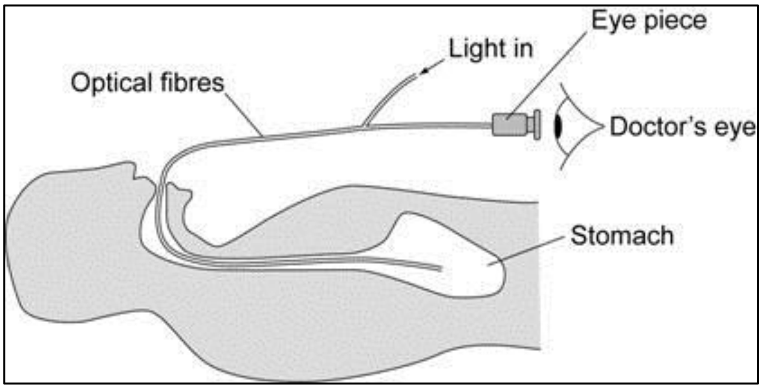
(1)

(b) (i) Complete the diagram to show the path taken by the light ray as it travels through the optical fibre.



(2)

(ii) The diagram shows an endoscope being used by a doctor to look inside a patient's stomach. Light travels into the stomach through a bundle of optical fibres.



The following sentences describe how the endoscope allows the doctor to see inside the patient's stomach. The sentences are in the wrong order.

Q Light passes through a bundle of optical fibres into the patient's stomach.

R The inside of the stomach reflects some of the light.

S The optical fibres take the light to an eyepiece.

T The doctor looks through the eyepiece to see inside the patient's stomach.

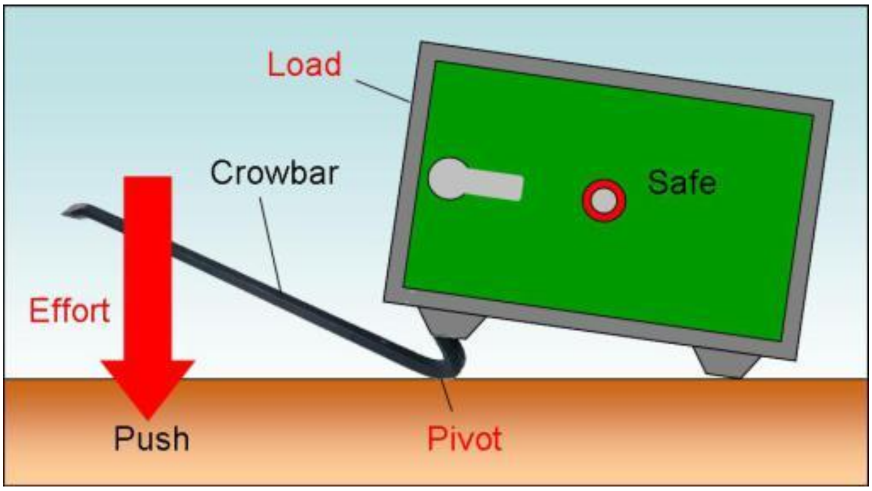
U The reflected light passes through a second bundle of optical fibres.

Arrange these sentences in the correct order. Start with letter **Q**.

Q → ☐ → ☐ → ☐ → ☐

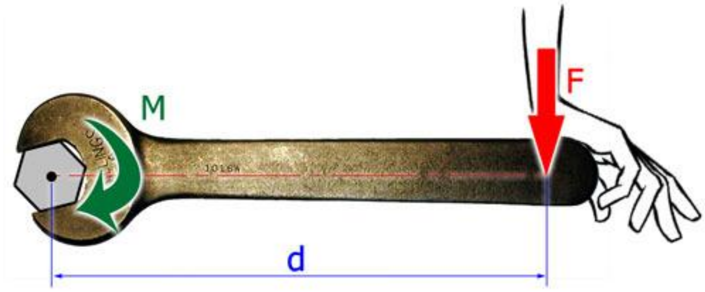
(3)
(Total 6 marks)

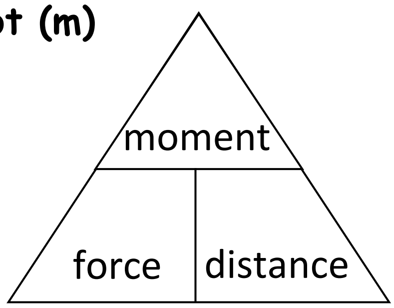
Moments, pendulum and centre of mass



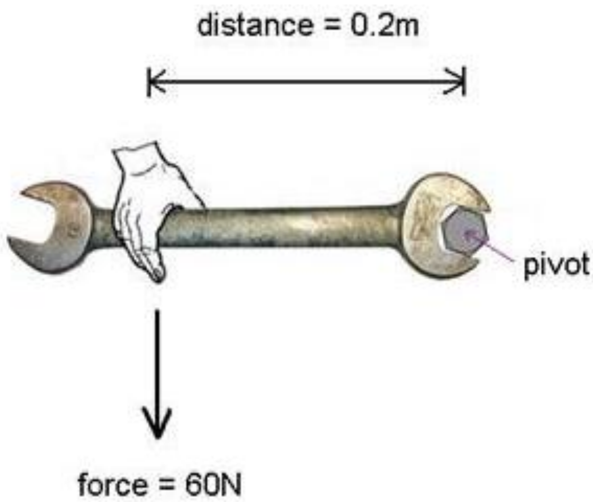
Moments describe the turning effect of a force. A lever is a prime example of a moment. The **load** is what you are trying to move, the ***effort*** is the force you are applying to move the load and the **pivot** is the point around which the lever is moving or rotating. Moments are measured in Newton meters (Nm) and are calculated using the following equation:

moment (Nm) = force (N) x distance from force to pivot (m)





The moment is bigger if the force is bigger or if the distance is increased. Any turning effect is a moment, using a spanner, turning a tap, opening a door etc.



Here is a sample question.

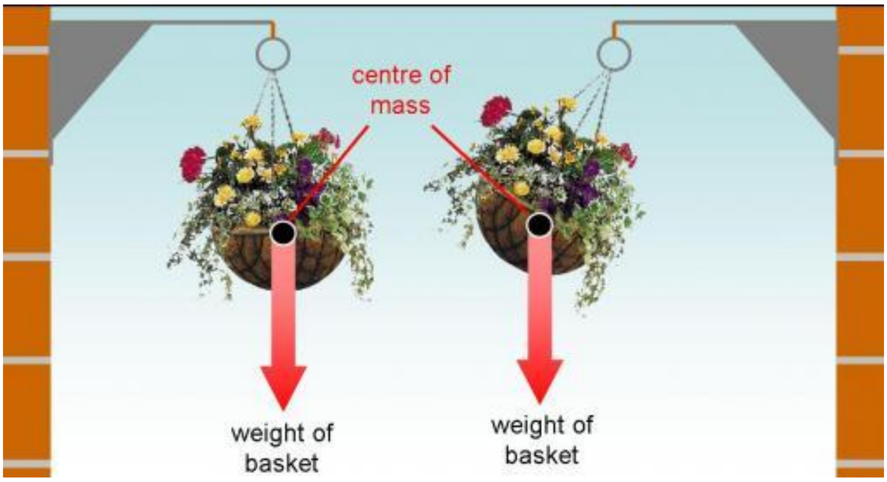
What is the moment in the question on the left.

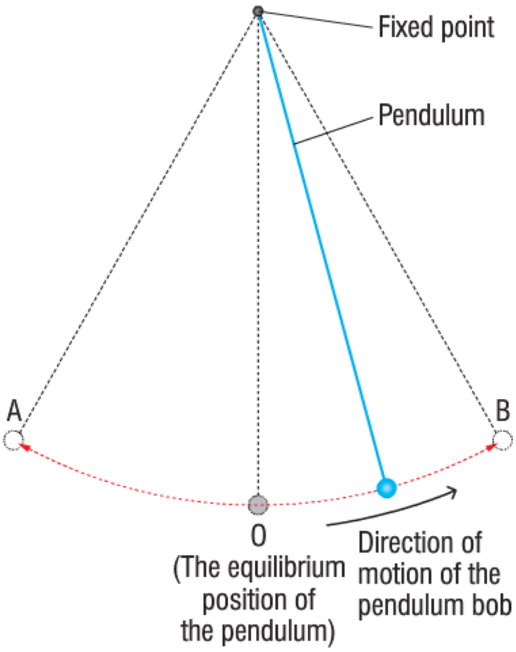
Moment = force x distance

Moment = 60N x 0.2m

Moment = 12 Nm

The centre of mass (or gravity) of an object is the point where all the weight of the object appears to act or is concentrated. For an object hanging freely, it will come to rest with the centre of mass below the point it is suspended (or hanging) from.





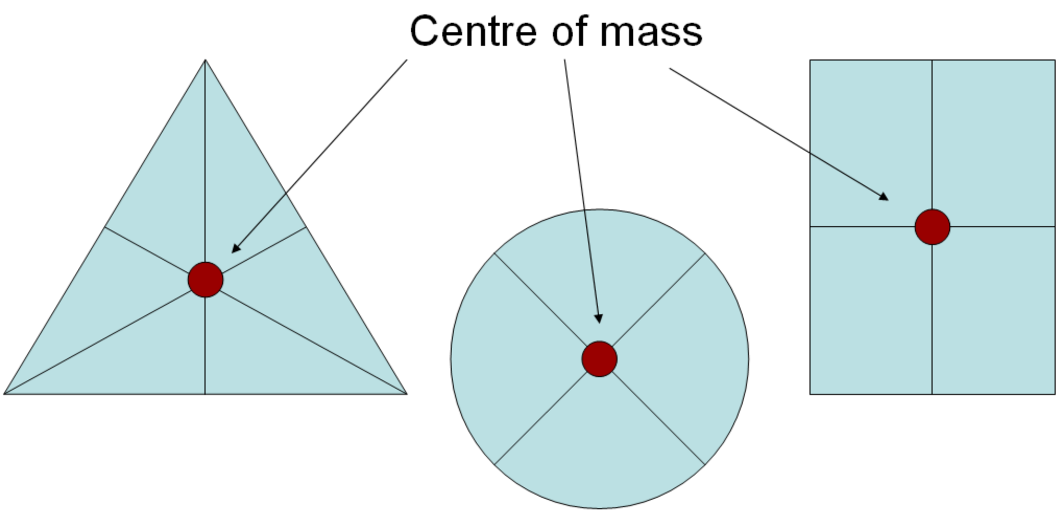
The fact that an object, when suspended, will come to rest with its centre of mass beneath the suspension point is useful for pendulums. A pendulum consists of a mass swinging back and forth. The period of a pendulum is the time it takes for one complete cycle of motion e.g. in the diagram it would be the time it takes to go from point A to point B and back to point A (from A back to A). The period and the frequency (the number of cycles every second measured in Hertz, Hz) is related by the following equation.

$$T = \frac{1}{f}$$

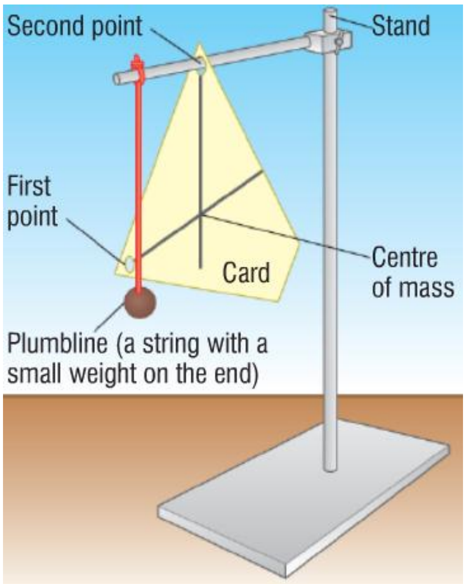
$$T \text{ is the period } (s)$$
$$f \text{ is the frequency } (Hz)$$

There is only one thing that will affect the period of a pendulum and that is the length of the string

- Longer string means a bigger period
- Shorter string means a smaller period

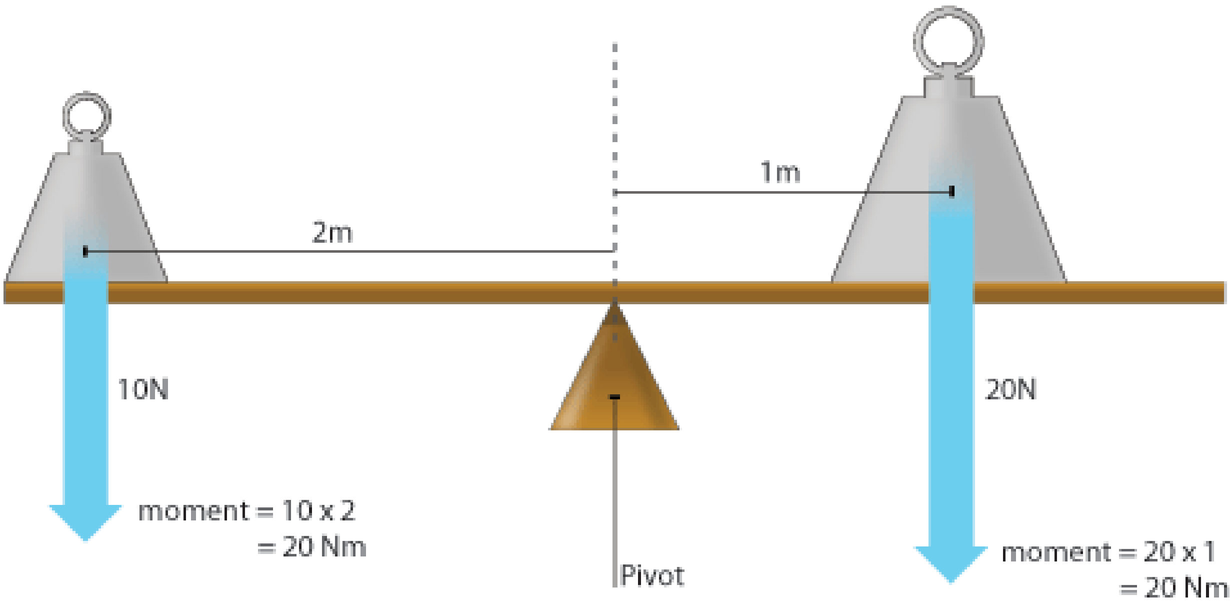


To find the centre of mass of a symmetrical body then it is along the axis of symmetry Where the lines cross is where the centre of mass is. This is why you can balance a ruler on the end of your finger if you position it correctly i.e. so the centre of mass is on the tip of your finger. See saws also use this principle.

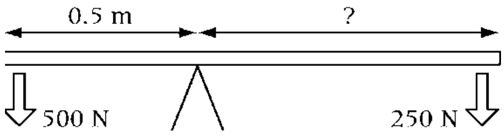


For unsymmetrical or irregular shaped objects you can find the centre of mass by freely suspending the object from a point (see diagram on the left). If you then use a 'plumbline' (a mass on a piece of string) you can draw a line from the suspension point along the plumbline. Now suspend the object from another point and do the same thing. When the 2 lines cross is where the centre of mass is.

Moments can also act in pairs like in see saws, there is a **clockwise moment** and an **anti clockwise moment**. When the clockwise moment is the same as the anti clockwise moment then the turning effects are balanced.



EXAMPLE QUESTION



The sew saw to the left is balanced.

The anticlockwise moment = the clockwise moment

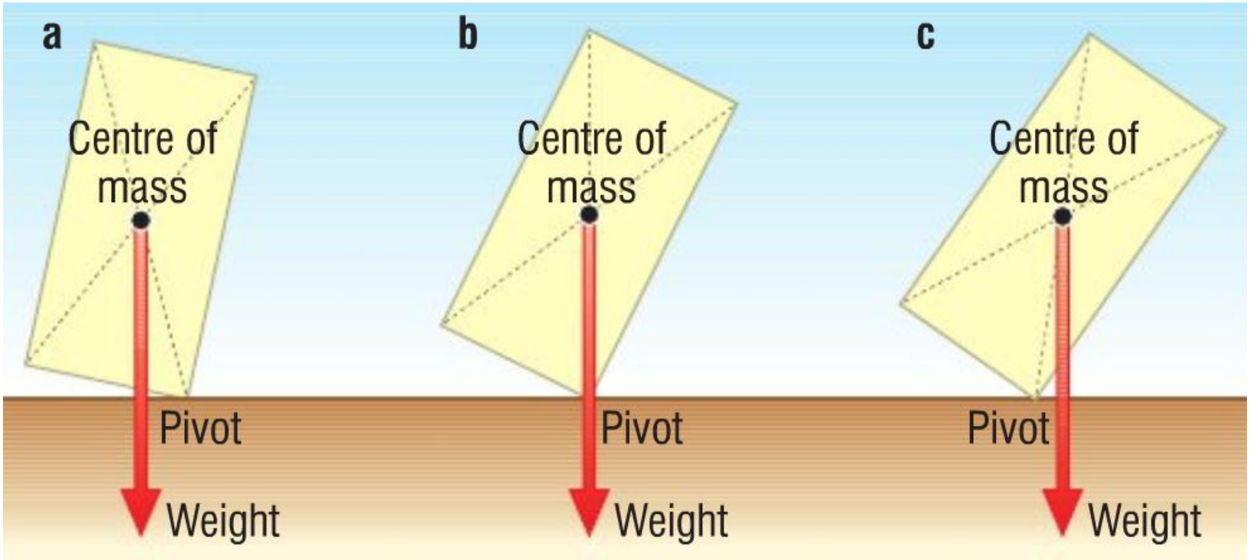
500 x 0.5 = the distance from the pivot x 250 N

250 = the distance from the pivot x 250 N

250 ÷ 250 = distance from pivot

1 m = distance from pivot

How stable an object is depends on the centre of mass and the size of the base. If a moment acts on an object it will return to its original position provided the centre of mass is still acting within the base. If the centre of mass is acting outside the base then it will fall over as there is a resultant moment now acting.

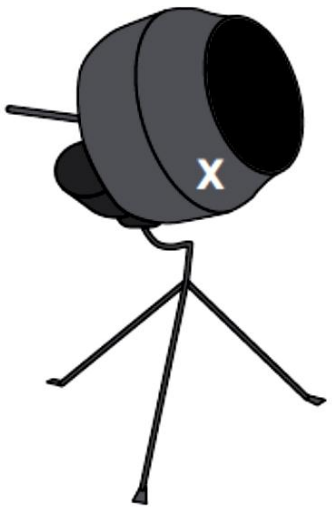


An object can be made more stable by

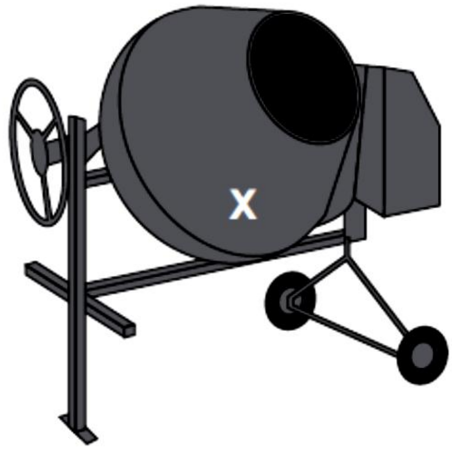
1. having a lower centre of mass
2. having a wider base

Sample Question 10

4 The diagrams show two concrete mixers.



Concrete mixer **A**



Concrete mixer **B**

On each diagram, the centre of the white **X** marks the centre of mass of the concrete mixer and its contents.

4 (a) Complete the sentence to explain what the term *centre of mass* means.

The centre of mass of a concrete mixer and its contents is ....

....

....

(1 mark)

4 (b) Both diagrams are drawn to the same scale.

Concrete mixer **B** is more stable than concrete mixer **A**.

The two features which make concrete mixer **B** more stable are:

1 ....

....

2 ....

....

(2 marks)

4 (c) Use the terms 'line of action of the weight' and 'resultant moment' to explain why a stable concrete mixer does not fall over when it is given a small push.

....

....

....

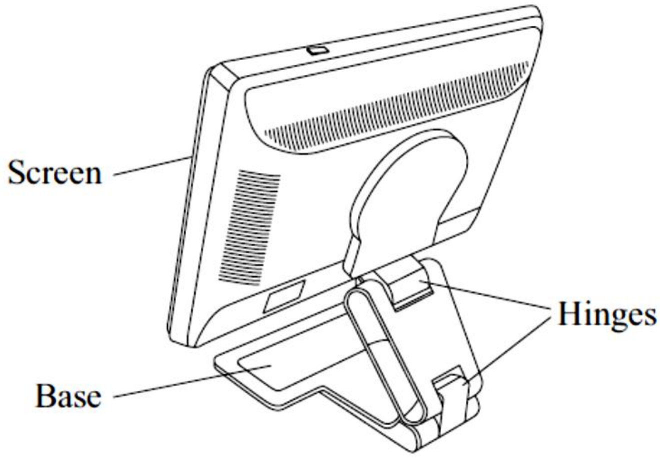
....

....

(2 marks)

Sample Question 11

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



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

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

....

....

....

....

(2 marks)

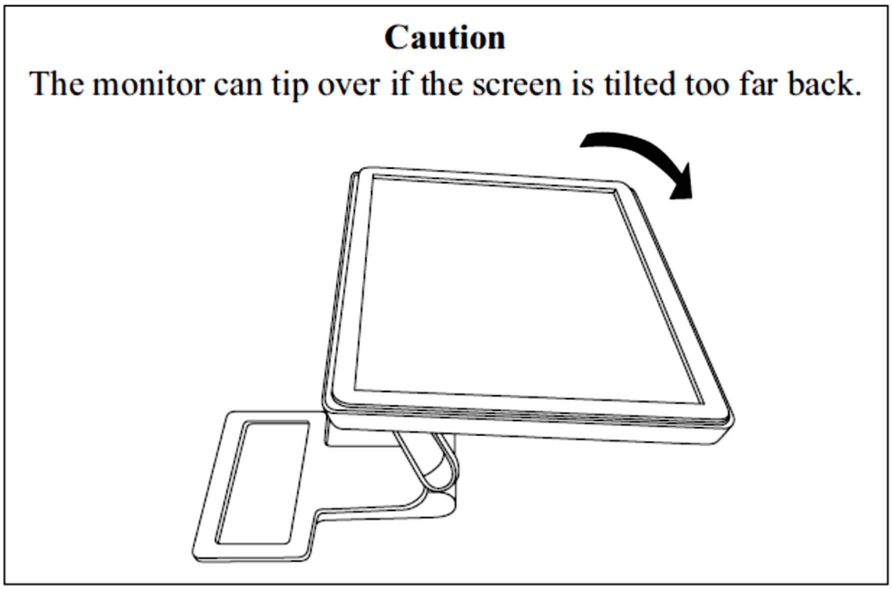
4 (a) (ii) State the relationship between the total clockwise moment and the total anticlockwise moment about any axis of the monitor when it is stable.

....

....

(1 mark)

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



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.

....

....

....

....

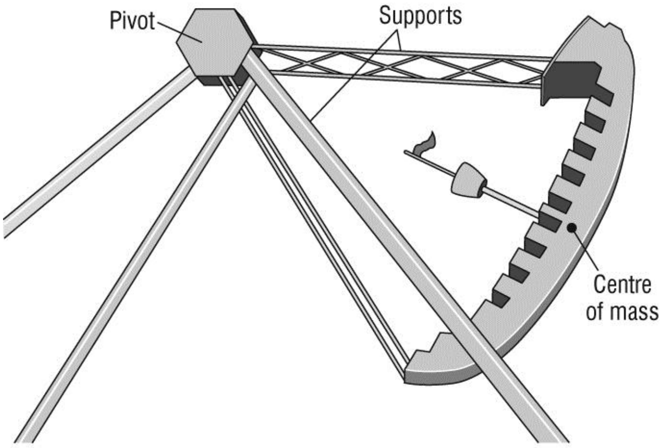
....

....

(3 marks)

Sample Question 12

The 'pirate ship' is a very common amusement park ride. The ride is simply a giant pendulum.



The designers of the ride wanted there to be three seconds between the highest points on each side of the ride.

a What would the time period of this ride be?

.... (1)

b Calculate the frequency of the ride.

Write down the equation you use. Show clearly how you work out your answer and give the unit.

....

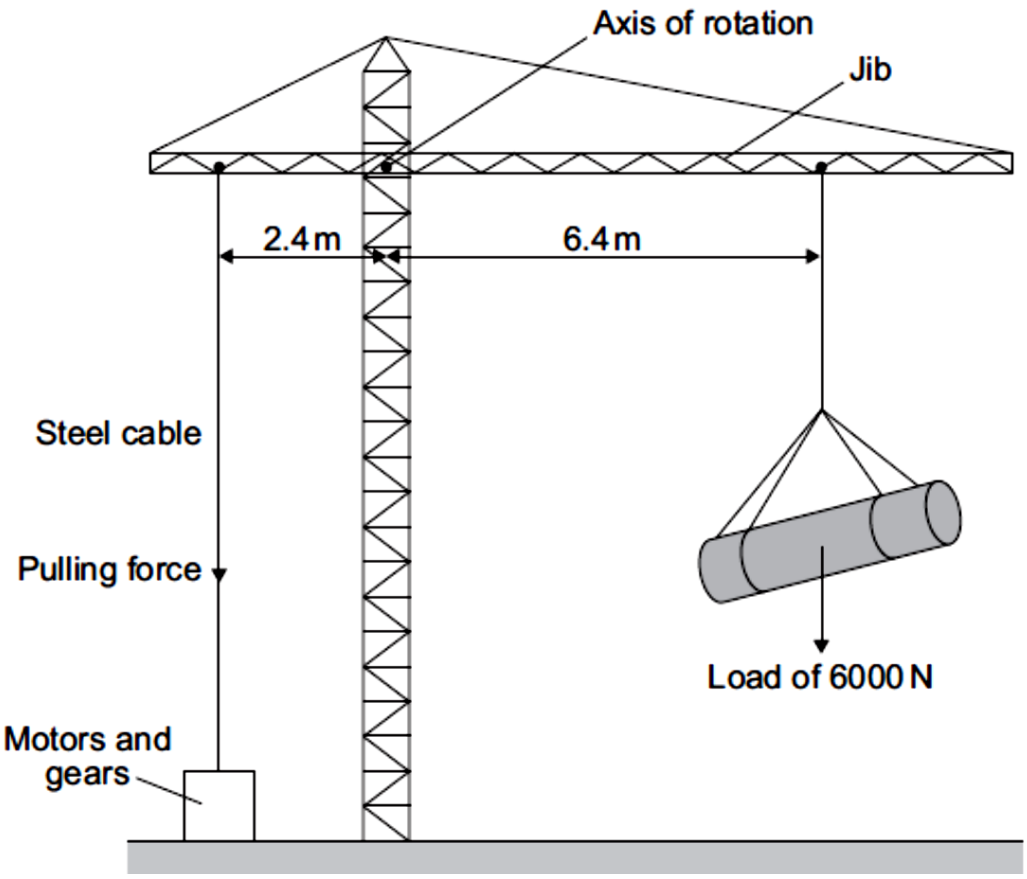
.... (2)

c When the ride was sold to another amusement park, the dimensions of the ride were reduced. As a result of this, the distance between the pivot and the centre of mass of the ship was reduced. How would this affect the time period?

.... (1)

Sample Question 13

6 The diagram shows a design for a crane. The crane is controlled by a computer.



The purpose of the motors and gears is to change the pulling force in the steel cable. This is done so that the jib stays horizontal whatever the size of the load or the position of the load.

Use the equation in the box to answer questions (**a**) and (**b**).

moment	=	force	×	perpendicular distance from the line of action of the force to the axis of rotation

6 (a) Calculate the moment caused by the load in the position shown in the diagram.

Show clearly how you work out your answer and give the unit.

....

....

Moment = ...

(3 marks)

6 (b) Calculate the pulling force that is needed in the steel cable to keep the jib horizontal.

Show clearly how you work out your answer.

....

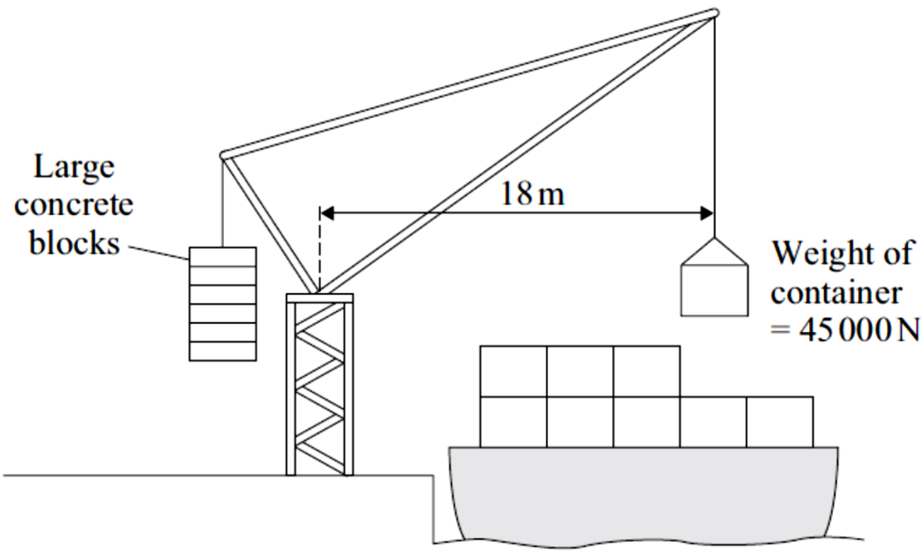
....

Pulling force = ... N

(2 marks)

Sample Question 14

3 The diagram shows a crane which is loading containers onto a ship.



3 (a) Use the equation in the box to calculate the moment of the container which is being loaded.

moment = force ×	perpendicular distance from the line of action of the force to the axis of rotation	

Show clearly how you work out your answer and give the unit.

....

....

Moment of the container = ...

(3 marks)

3 (b) Suggest and explain the purpose of the large concrete blocks.

....

....

....

....

....

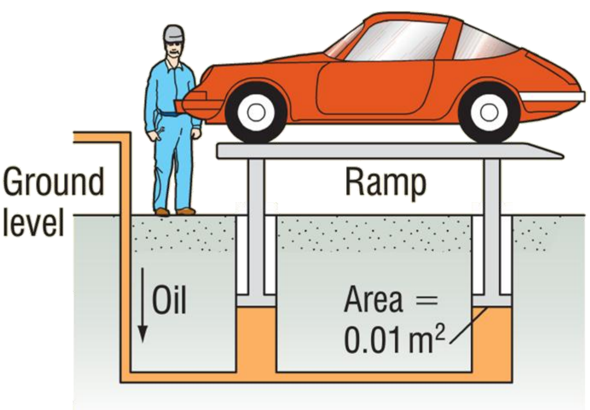
(3 marks)

Hydraulics

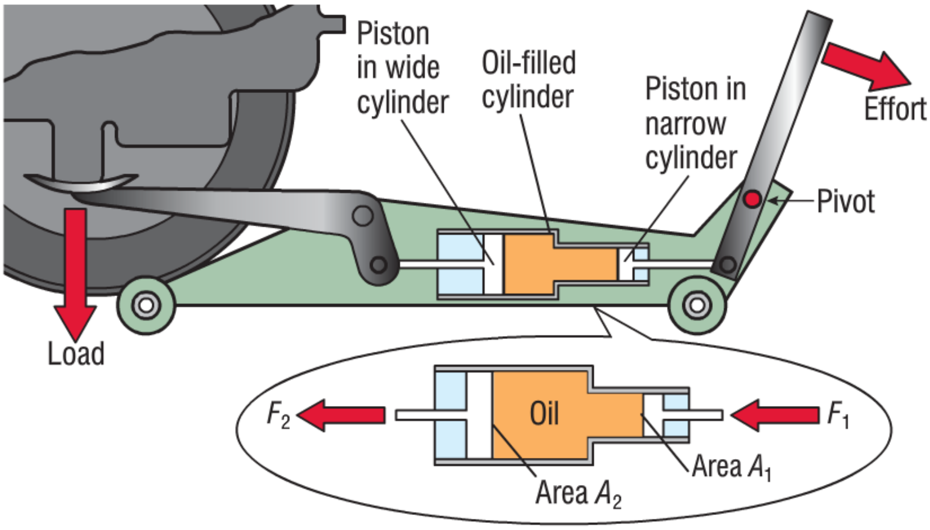
Hydraulics use pressure in order for them to work. **Pressure** is measured in **Pascal (Pa)** and it is the force per unit area (**N/m^3**). Pressure is calculated using

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

$$P\ is\ pressure\ (Pa\ or\ N/m^3)$$
$$F\ is\ force\ (N)$$
$$A\ is\ area\ (m^3)$$



A hydraulic system uses a liquid to drive a piston. Liquids are used because they are virtually incompressible (can't be squashed into a smaller volume). This means that **pressure** in a liquid gets **transmitted equally** in **all directions**.



Hydraulics can be used as **force multipliers**. The diagram shows an example of a hydraulic jack where the areas are different at each end. Since the pressure is equal throughout the jack this means that the pressure at end 1 (the effort side) is equal to the pressure at end 2 (the load side).

$$P_1 = P_2 \qquad OR \qquad \frac{F_1}{A_1} = \frac{F_2}{A_2}$$

So in the above example F_2 is bigger that F_1 because end 2 has a much bigger area. The force must be bigger as the pressure is the same throughout.

<u>EXAMPLE QUESTION</u>

In the above diagram if A_1 = 0.1m^3, F_1 = 5N, and A_2 is 0.4m^3 what would the force F_2 be equal to?

$$\frac{F_1}{A_1} = \frac{F_2}{A_2} \qquad rearrange\ F_2 = \frac{F_1}{A_1} \times A_2$$

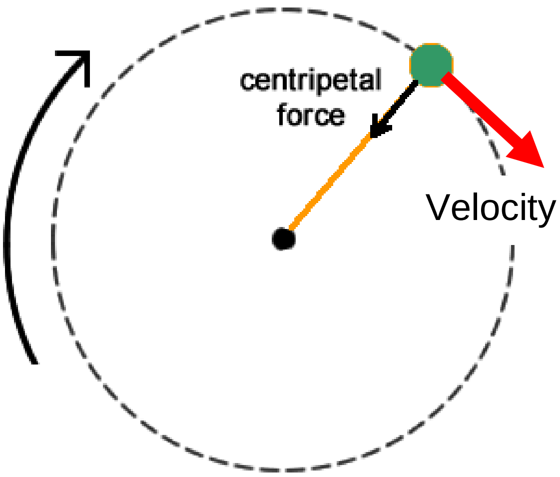
$$F_2 = \frac{5}{0.1} \times 0.4 \qquad F_2 = 20N$$

Force multipliers means that the size of a force can be increased or decreased by changing the areas. By having a smaller area on the effort side (the side where you are applying a force) you can increase the force produce on the load side and vice versa.

<u>**Circular motion**</u>

If an object is moving in a circular motion then there is a force acting towards the centre of the circle – this force is called the <u>**centripetal force**</u>.

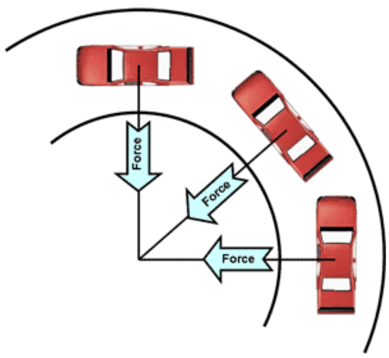
Consider a mass on the end of a string being swung around in a circle. The tension in the string is providing the centripetal force. This mass is constantly accelerating towards the centre of the circle. When this object is spinning around it's direction is constantly changing which means it's velocity is constantly changing. REMEMBER: Speed is how fast an object is going; velocity is how fast you're going in a particular direction. So even if the object is being swung around at a constant speed its velocity won't be constant because it is changing direction the whole time.



The **centripetal force** can be **increased** if

1. the **mass** of the object is **increased**
2. the **speed** of the object is **increased**
3. the **radius** of the circle **decreases**

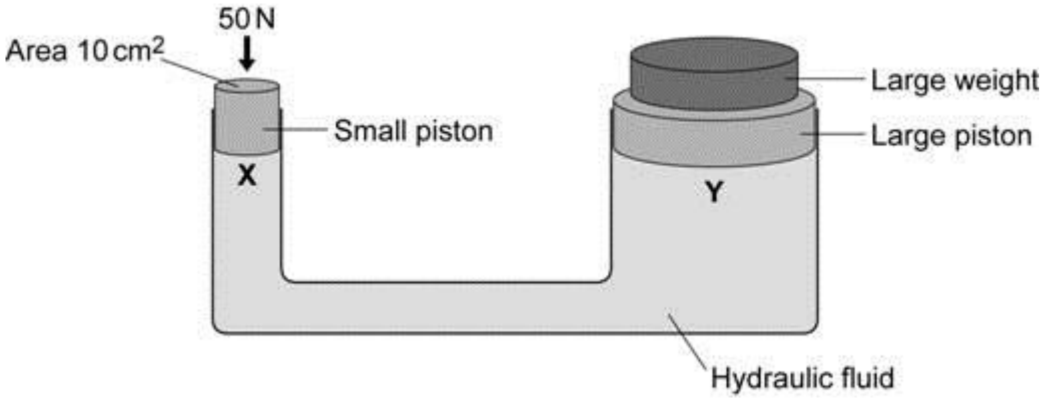
This force applies for any object moving in a circle, e.g. planets, planes, cars etc. An example is a vehicle going around a corner. The centripetal force is being provided by the friction of the car's tyres against the road.



Planets that orbit a Star, and moons that orbit planets, are in orbit due to gravity. So the centripetal force for planets is provided by the gravitational force.

Sample Question 15

The diagram shows a simple hydraulic jack. The jack is designed to lift a large weight using a much smaller force.



(a) Complete the following sentence.

A hydraulic jack is an example of a .... multiplier.

(1)

(b) Calculate the pressure, in N/cm², created on the small piston by the force of 50 N pushing downwards.

Write down the equation you use, and then show clearly how you work out your answer.

....

....

....

....

....

....

Pressure = ... N/cm²

(2)

(c) Complete the following sentence.

The pressure at **Y** will be .... the pressure at **X**.

(1)
(Total 4 marks)

Sample Question 16

8 The London Eye is the largest observation wheel in the world.

The passengers ride in capsules. Each capsule moves in a circular path and accelerates.

8 (a) Explain how the wheel can move at a steady speed and the capsules accelerate at the same time.

....

....

....

(2 marks)

8 (b) In which direction does each capsule accelerate?

....

(1 mark)

8 (c) What is the name of the resultant force that causes the capsules to accelerate?

....

(1mark)

8 (d) The designers of the London Eye had to consider **three** factors which affect the resultant force described in part (c).

Two factors that increase the resultant force are

- an increase in the speed of rotation
- an increase in the total mass of the wheel, the capsules and the passengers.

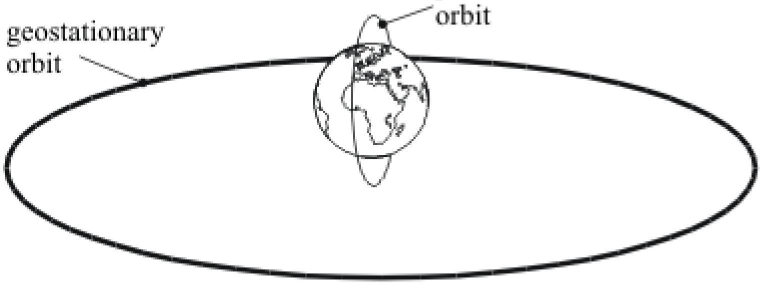
Name the other factor that affects the resultant force and state what effect it has on the resultant force.

....

....

(1 mark)

Sample Question 17



A satellite in stable Earth orbit moves at a constant speed in a circular orbit because there is a single force acting on it.

(i) What is the direction of this force?

....

....

(1)

(ii) What is the cause of this force?

....

(1)

(iii) What is the effect of this force on the **velocity** of the satellite?

....

(1)

(iv) In which of the orbits shown above would this force be bigger? Explain the reason for your answer.

....

....

(2)

(v) Explain why the kinetic energy of the satellite remains constant.

....

....

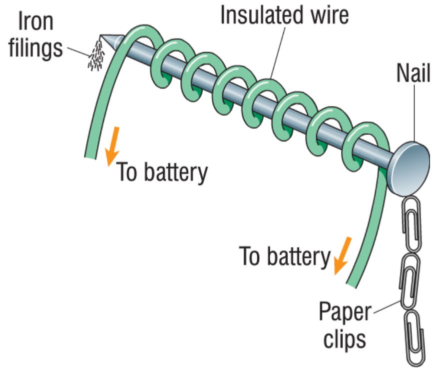
....

(2)

(Total 7 marks)

Electromagnets

Iron can be magnetised by wrapping a wire around the metal and passing a direct current (D.C.) through the wire. When a current passes through a wire it also creates a magnetic field around the wire. It is this magnetic field that magnetises the iron. The strength of the electromagnet can be increased

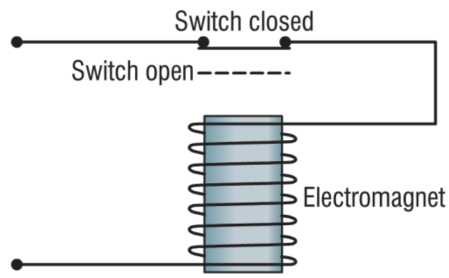


- wrapping the wire around the iron more times
- increasing the current through the wire

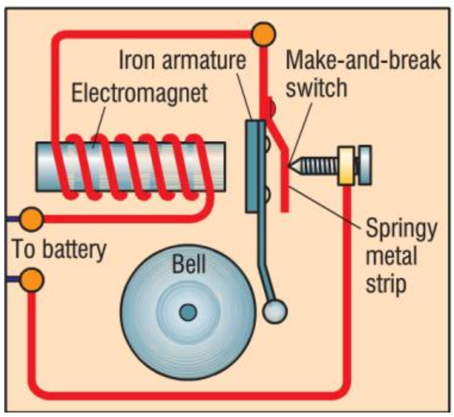
Iron is used as the core in an electromagnet because it can be strongly magnetised and easily loses it magnetism when the current is turned off.

Electromagnets have the obvious use as cranes in scrap yards by there are some other uses

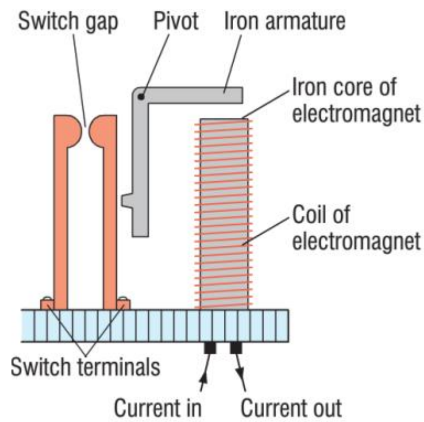
A **circuit breaker** is used to prevent damage to electrical devices. If the current is too high the electromagnet pulls open the switch stopping the electrical flow. This stops a high current going to your electrical appliances and prevents any damage occurring



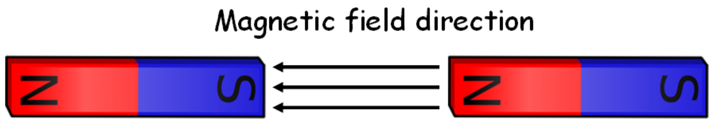
An **electrical bell** uses electromagnets. When the switch is closed the electromagnet pulls the 'hammer' towards the bell. But this then causes the circuit to break and the electromagnet stops working. The hammer then returns to it's normal position which closes the circuit again and the process continues.



A **relay** is used to switch electrical machines on or off (e.g. a motor). When the electromagnet pulls the iron armature down it also pushes the switch gap together. This means that a small current (in the electromagnet) is being used to switch on a larger current (in the electrical device e.g. motor).

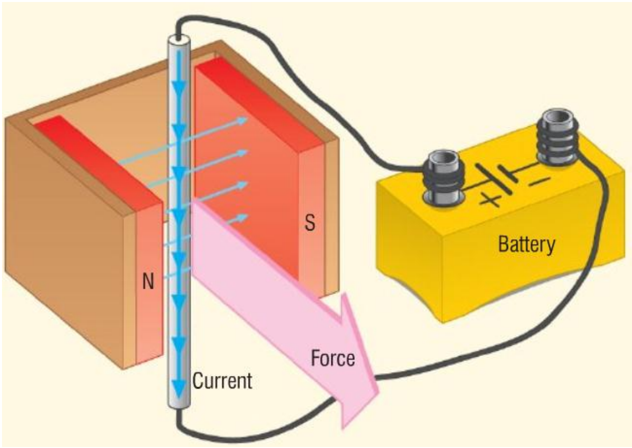


<u>Motor effect and electromagnetic induction</u>



The direction of a magnetic field goes from the north pole to the south pole of the magnet.

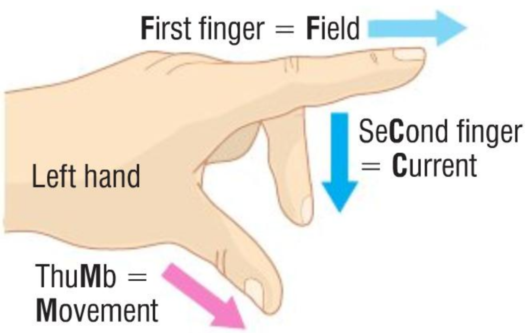
When a current carrying wire is placed into a magnetic field it experiences a



force. This is because an electric current in a wire produces a magnetic field around the wire. The size of the force can be increased by

- increasing the strength of the magnetic field
- increasing the size of the current

If the **<u>wire</u>** carrying the current is **<u>parallel</u>** to the **<u>magnetic field</u>** then it will **<u>not</u>** experience a **<u>force</u>**.

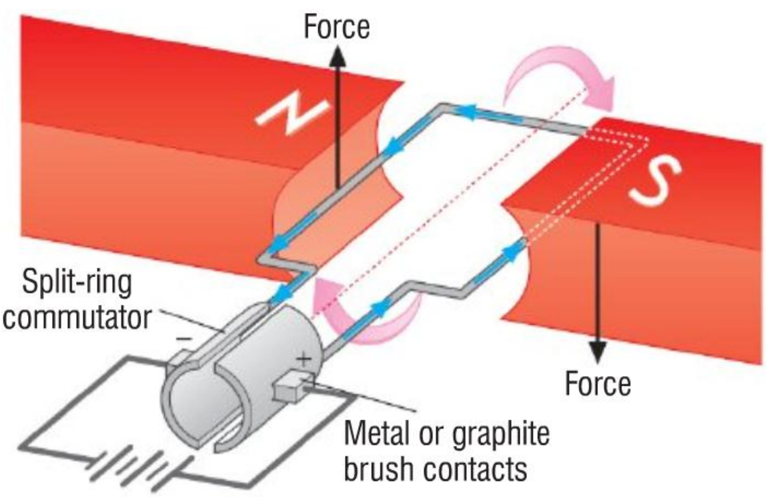


The direction of the force can be determine by using your left hand (Fleming's left hand rule).

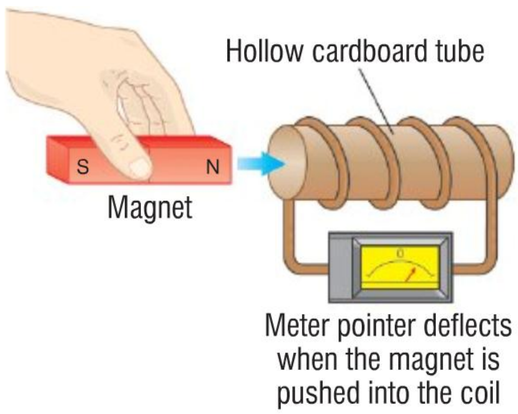
Index finger = magnetic field

Second finger = current

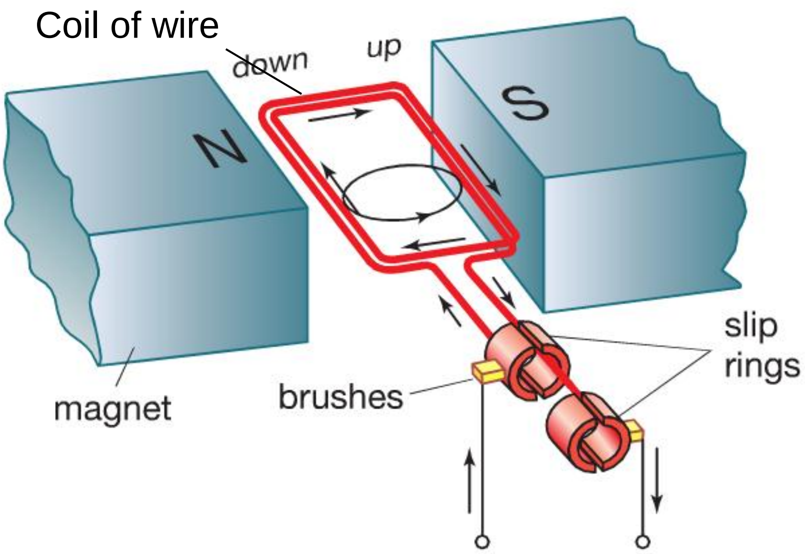
Thumb = direction of force



The motor effect is used in several devices such as electric drills, hair dryers, loudspeaker etc. A DC (direct current) motor has a split ring commutator. This allows the current in the coil of wire to change every half turn. This ensures the force is in the same direction and, as a result, the coil gets spun in the same direction each time.



A similar effect, called electromagnet induction, is when a changing magnetic field induces (creates) a current in a wire and a potential difference (voltage). When the magnet is pushed into the coil the current goes one way – positive current. When the magnet is remove the current goes in the opposite direction – negative current. The potential difference also changes in this way.

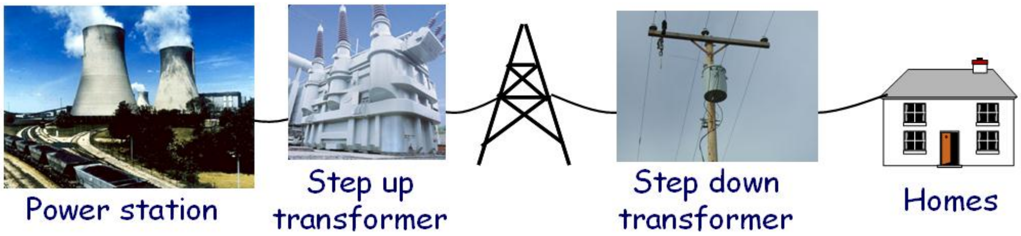


Electrical generators produce this **alternating current** (AC). When a coil of wire is spun within a magnet field (or a magnet spinning inside a coil of wire) the alternating current and voltage is produced when the wire 'cuts through' the magnetic field lines. The slip rings stop the wires from getting tangled. The brushes are in contact with the slip rings and take the alternating current from the coil of wire and pass it into the circuit.

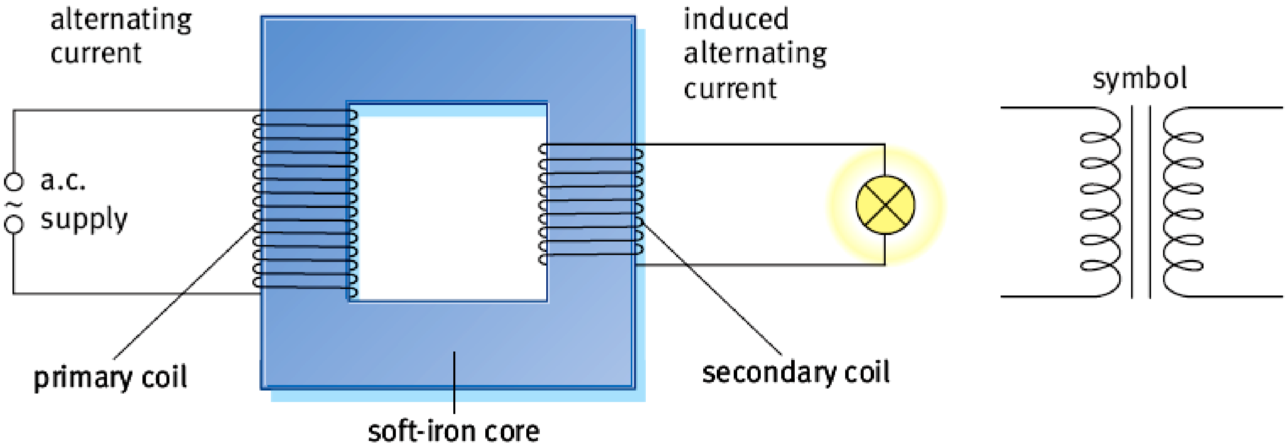
The size of the potential difference (voltage) produced can be increased by

- increasing the speed of rotation
- increasing the strength of the magnetic field
- increasing the number of 'turns' on the wire
- increasing the area of the coil

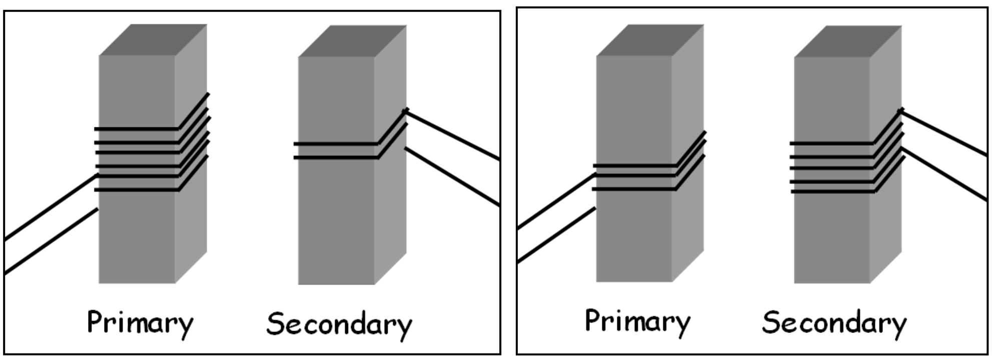
Mains electricity is generated this way in a power station and travels to you home via the national grid. The electricity at your home has a frequency of 50Hz and a voltage of 230V.



Transformers are used in the national grid in order to increase (step up) the voltage and decrease (step down) the voltage. The reason they are need is because there would be too much energy lost due to heat cause by friction in the wires.



Transformers are made of a magnetic material (iron core) with coils of wire wrapped around them. In a transformer there are primary coils and secondary coils. The primary coil is the one that initially receive the unchanged voltage, the secondary coil is where the voltage gets changed. When an alternating current passes around the iron core a changing magnetic field is induced. The changing magnetic field produces an alternating current (and voltage) in the secondary coil. Transformers only work with A.C. The number of turns around the coil will determine if the voltage is increased or decreased.



If the secondary coil has less turns then the primary coil it is a step down transformer (decreases voltage).

If the secondary coil has more turns then the primary coil it is a step up transformer (increases voltage).

Transformers are governed by the following equation:

$$\frac{\text{pd across primary, } V_p}{\text{pd across secondary, } V_s} = \frac{\text{number of turns on primary, } n_p}{\text{number of turns on secondary, } n_s}$$

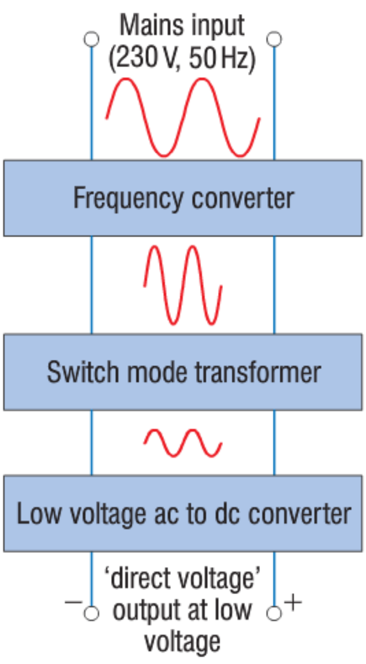
Power is equal to voltage times current (P = I × V) so if we assume that transformers are 100% efficient then that means that

$$V_p \times I_p = V_s \times I_s$$

$V_p = Primary\ coil\ voltage$ $I_p = Primary\ coil\ current$

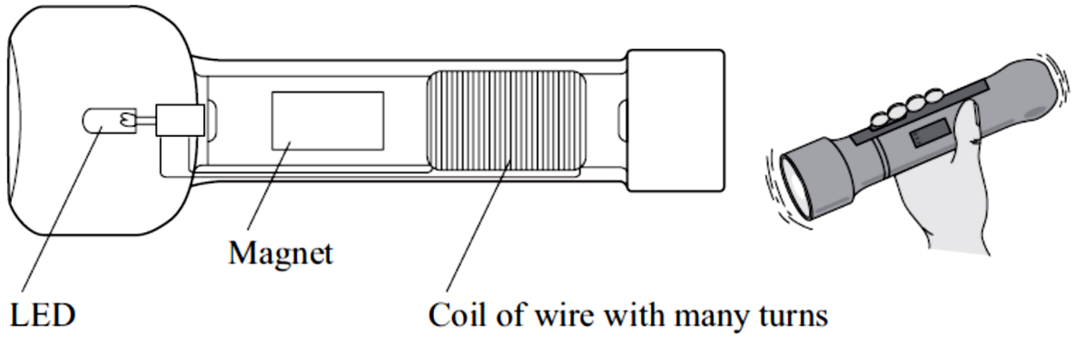
$V_s = Secondary\ coil\ voltage$ $I_s = Secondary\ coil\ current$

Transformers are commonly used in laptop and mobile phone charges but these transformers are **<u>'switch-mode transformers'</u>**. They operate at a much higher frequency, around 50 000Hz to 200 000Hz (50 kHz to 200 kHz) because they have a ferrite core rather than an iron core. They are usually much lighter and smaller than conventional transformers. A mobile phone charger for example (see diagram) will change the frequency of the mains electricity to a much higher frequency. The voltage is then changed to a suitable level and finally the A.C. is converted to D.C. to charge your phone. Switch mode transformers are very efficient. Even when they are switched on (i.e. plugged in) but no load is applied (i.e. no phone/laptop connected) they use very little power.



Sample Question 18

2 The diagram shows some parts of a torch which works without batteries.
The coil is part of a complete circuit with the LED (light-emitting diode).
You have to shake the torch for a short time and then it is ready to use.



2 (a) Arrange the letters, **A**, **B**, **C**, **D** and **E**, in the correct order to explain how shaking the torch produces an electric current.

A An electric current is induced in the circuit.

B The magnetic field cuts through the coil.

C The magnet moves in and out of the coil.

D A potential difference (p.d.) is induced across the ends of the coil.

E The torch is shaken to and fro.

The first letter has been done for you.

E				

(2 marks)

2 (b) Give **two** changes which you would make to the design of the torch to increase the size of the induced potential difference.

1 ....

....

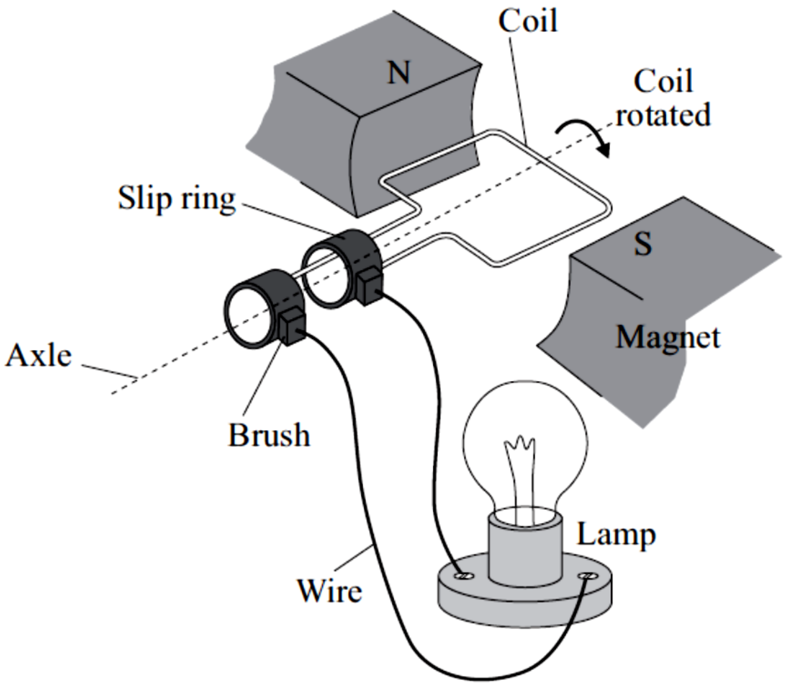
2 ....

....

(2 marks)

Sample Question 19

7 The diagram shows a generator.
When the coil is rotated around the axle, a current is produced and the lamp lights up.



7 (a) Explain the purpose of the slip rings and brushes.

....

....

....

(2 marks)

7 (b) Explain how this generator gives an a.c. rather than a d.c. output.

....

....

....

(2 marks)

7 (c) In this design, the generator effect occurs because the coil rotates in a magnetic field.

How else can a generator effect occur?

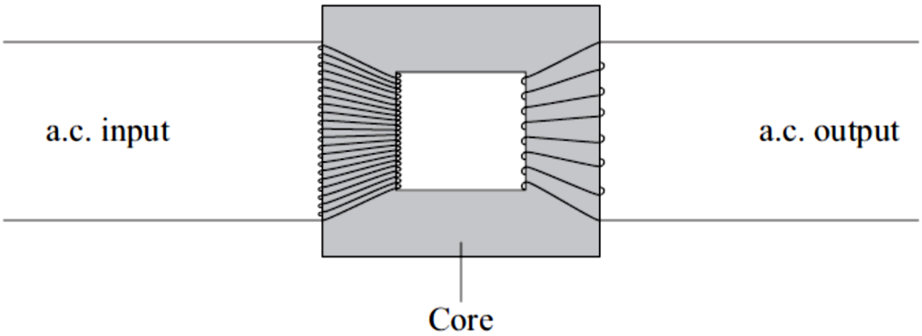
....

....

(1 mark)

Sample Question 20

6 (a) The diagram shows a transformer.



(i) Is the transformer in the diagram being used as a step-up transformer or as a step-down transformer?

Put a tick (✓) in the box next to your answer.

a step-up transformer ☐

a step-down transformer ☐

Explain your answer.

....

....

(1 mark)

(ii) Why is insulated wire, and not uninsulated wire, used to make the coils?

....

....

(1 mark)

(iii) Why is the core made of iron?

....

....

(1 mark)

(b) A transformer has 500 turns on its primary coil and 7500 turns on its secondary coil. The potential difference across the primary coil is 150 volts.

Use the equation in the box to calculate the potential difference 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 across the secondary coil = ... volts

(2 marks)

(c) Step-down transformers are used between power lines and people's houses.

Explain why.

....

....

....

(2 marks)

(d) Before 1926, large towns had their own local power stations. After 1926, these power stations were connected to form the National Grid.

Explain the advantage of having a National Grid system.

....

....

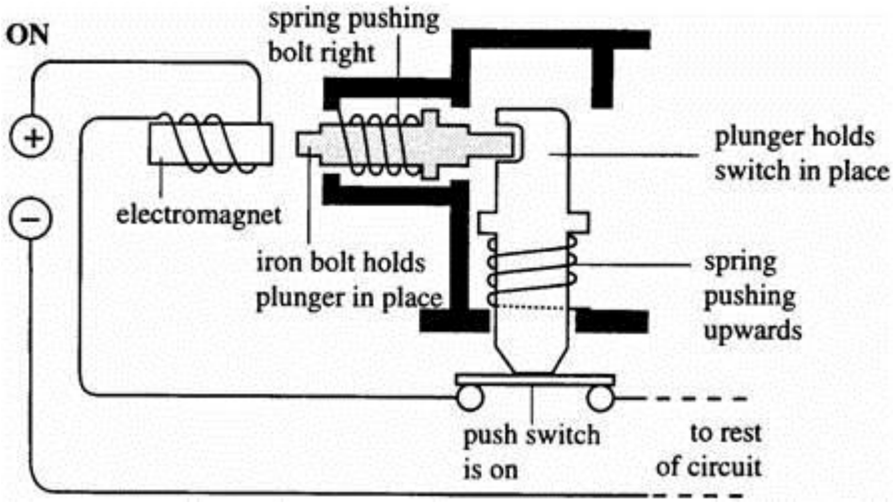
....

....

(2 marks)

Sample Question 21

A fault in an electrical circuit can cause too great a current to flow.
Some circuits are switched off by a circuit breaker.



One type of circuit breaker is shown above. A normal current is flowing.
Explain, in full detail, what happens when a current which is bigger than normal flows.

....

....

....

....

....

....

....

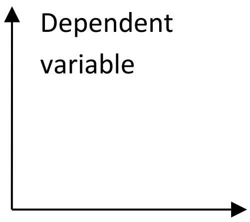
....

(Total 4 marks)

How science works

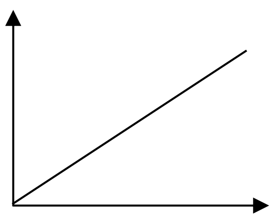
The independent variable is what is changed during an experiment
Remembering Tip: Independent starts with I so it is the variable that I change
The dependent variable is what you measure in the experiment i.e. the results
The control variables are the things you want to keep the same during an experiment.

When plotting a graph for your results you generally plot the dependent variable along the y-axis and the independent variable along the x-axis.



Your independent/dependent variable can either be continuous or categoric.
Continuous variables are numbers 1.2, 5.76, 3.0 etc – draw a line graph
Categoric variables are categories e.g. colours, metals – draw a bar chart

Describing results



- This graph is showing a positive correlation, i.e. as one variable increases so does the other and the line goes up.
- A negative correlation is when one variable goes up the other goes down, the line would go downwards.

Experimental procedure

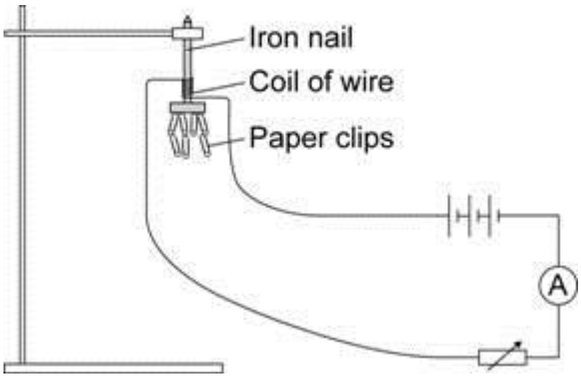
Prediction: What you think will happen
Plan: How you are going to carry out your experiment

Conclusion: What you have found out from the experiment
Fair test: When you make sure each experiment is set up the same way so the results can be compared fairly
Repeatable: In experiments you usually repeat measurements and take a mean (average). This is to ensure you are getting the same results.
Reproducible: If another experimenter can get the same results as you using their equipment then your finding are correct.
Range: The lowest to highest value you tested
Anomalous: Results that don't fit in/follow the pattern of the other results

When making a conclusion about an experiment, that conclusion is only valid for the range investigated.

Sample Question 22

The diagram shows the equipment used by a student to investigate the strength of five different electromagnets.



The stronger the electromagnet, the more paper clips it will hold.

(a) Why is it important that the paper clips used in the investigation are all the same size?

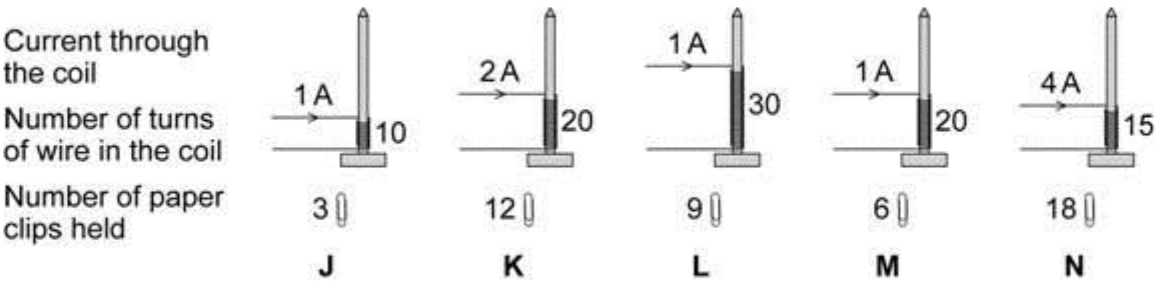
....

....

....

(1)

(b) The five electromagnets, **J**, **K**, **L**, **M** and **N**, used by the student are shown below.
Each electromagnet was made by wrapping lengths of insulated wire around identical iron nails.



The student wants to find out how the strength of an electromagnet depends on the number of turns of wire in the coil.

Which electromagnets should the student compare in order to do this?

....

(1)

(c) The student concluded:

"The strength of an electromagnet is always directly proportional to the number of turns on the coil."

(i) Explain how the data from the investigation supports the student's conclusion.

....

....

....

....

(2)

(ii) The student makes one more electromagnet by winding 100 turns onto a nail.

Before testing the electromagnet, the student predicted the number of paper clips that the electromagnet would hold when the current is 1 amp.

How many paper clips should the student predict that the electromagnet would hold?

Show clearly how you work out your answer.

....

....

number of paper clips = ...

(2)

(iii) When the student tested the electromagnet it held 20 paper clips.
This is not what the student predicted.

Explain what the student should do when new data does not seem to support the prediction that was made.

....

....

....

....

....

....

....

(3)
(Total 9 marks)

SOLUTIONS TO EXAM QUESTION

Question 1

1(a)	20 000	accept any unambiguous indication	1
1(b)	kilohertz	credit misspellings credit '1000 hertz' or '1000 Hz' accept 1000 oscillations/beats/waves <u>per second</u>	1
1(c)(i)	cleaning (e.g. something delicate such as a watch)	**or** quality control/flaw detection credit any appropriate extra Specification response e.g. sonar	1
1(c)(ii)	pre-natal (scanning)	do **not** credit just 'scanning'/medical scanning credit any appropriate extra Specification response e.g. destruction of (kidney) stones or cleaning teeth	1
1(d)	8 (μs)		1
1(e)	distance (1) between the <u>boundary</u> and the detector (1)	accept 'between the <u>boundary</u> and the source' accept any correct use of speed = distance/time	2
1(f)	examples publish/tell doctors/the public (1) ... their evidence/results/research/data (1) carry out more research/tests (1) ... to make sure/check reliability (1)	allow a wide variety of appropriate responses valid point (1) appropriate example/qualification/expansion/etc. (1) allow just 'stop using them/ultrasonic waves' (1) allow using them (only) for industrial purposes (1)	2

Question 2

(a) (i) X-rays or gamma rays

for 1 mark

1

(ii) passes through flesh;
stopped by bone/absorbed

for 1 mark each

2

(b) *idea that* X-rays cause mutations

gains 1 mark

but X-rays can cause/increase chance of mutations

gains 2 marks

mutations usually harmful/produce abnormal growth
serious effect on growing foetus/rapidly growing cells

each for 1 mark

[7]

Question 3

Quality of written communication

correct use of **three** <u>scientific</u> terms from speed / velocity, reflection, density, time, boundary

1

any **three** from:

different tissues have different densities

ultrasound travels at different speeds / velocities in different tissues

reflection

accept bouncing back

from tissue boundaries

time taken to return

3

[4]

Question 4

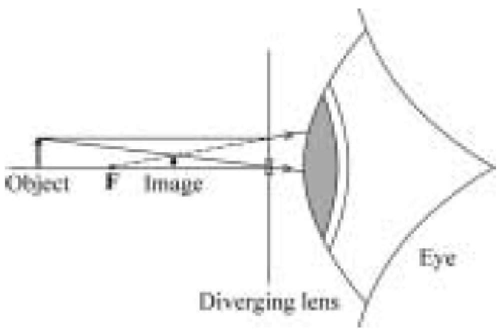
5(a)(i)	3		1
5(a)(ii)	30 000 **or** 10 000 × their (a)(i) correctly calculated		1

5(a)(iii)	any **two** from: • frequency is above 20 000 (Hz) • frequency is above the upper limit of audible range • upper limit of audible range equals <u>20 000</u> (Hz) • it is ultrasound/ultrasonic	accept the frequency is 30 000 ignore reference to lower limit	2

5(b)(i)	wave (partially) <u>reflected</u>		1
	at crack to produce **A** and end of bolt to produce **B**	accept at both ends of the crack	1

5(b)(ii)	0.075 (m)	allow **2** marks for time = 0.0000125 allow **1** mark for time = 0.000025 answers 0.15 **or** 0.015 **or** 0.09 gain **2** marks answers 0.18 **or** 0.03 gain **1** mark the unit is not required but if given must be consistent with numerical answer for the available marks	3

Question 5

(a)	straight line from the tip of the object … straight through the centre of the lens (1) … parallel to the axis, then diverges from the lens as if from F (1) image drawn from where **these** lines intersect, vertically to the axis (1)	**example** 	3
(b)	any **two** from: • smaller (than the object) • (both) upright • image is virtual / imaginary (whereas object is real)	no errors carried forward from the candidate's diagram mark first **two** points given	2

Question 6

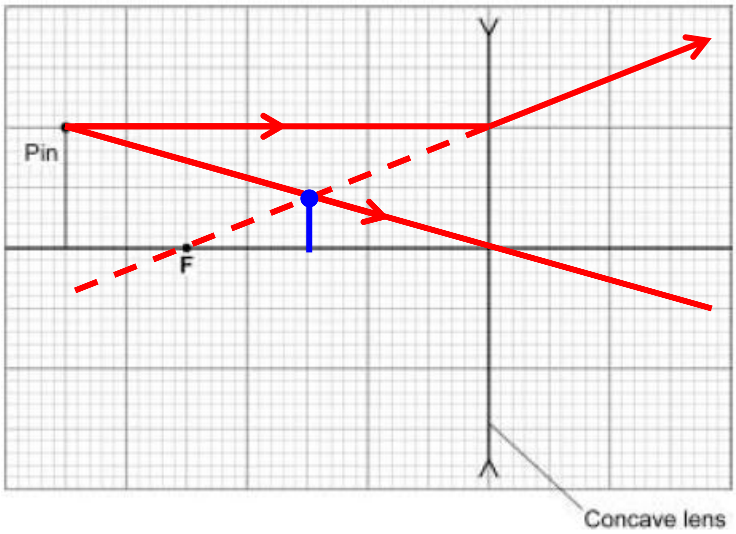
(a) 1.59

accept an answer that rounds to this

*allow **1** mark for correct substitution into correct equation*

ie refractive index = $\frac{\text{sine } 16^\circ}{\text{sine } 10^\circ}$

2



(b)

2 lines correctly drawn from the top of the pin through the lens

*allow **1** mark for each*

2

position of image correct

image must be upright

1

[5]

Question 7

(a) (i) converging / convex / biconvex

1

(ii) focal (points) **or** foci

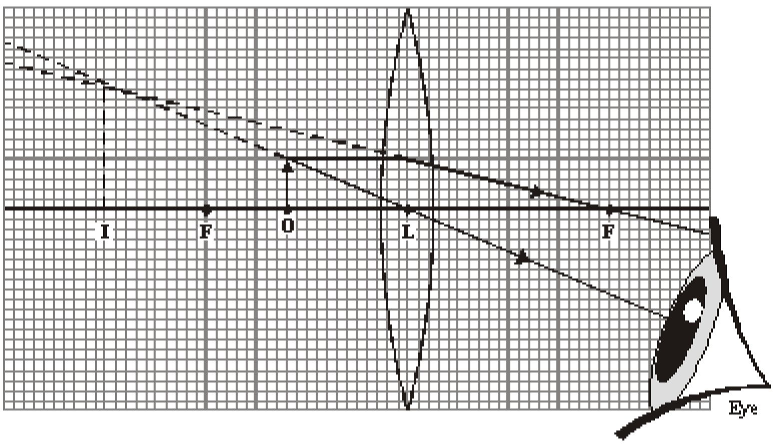
*accept focuses **or** focus (point)*

1

(iii) (principal) axis

1

(iv)



all lines drawn with a ruler for full marks

no ruler, penalise **1** mark from first four

last mark can still be awarded

double refraction drawn could get **4** out of 5 marks

ray that continues from the top of the object through L to the eye

1

horizontal ray from the top of the object, refracted by the lens and continued through F on the r.h.s. to the eye

1

back projections of these rays (shown as dotted lines)

1

image 25 mm high at 61 mm left of L(tolerance 1 mm ± vertically, 2 mm ± horizontally)

1

*at least one arrow shown on real ray and towards the eye but do **not** credit if contradicted by other arrow(s)*

1

(v) formed where imaginary rays intersect / cross **or** not formed by real rays

accept (virtual image) is imaginary
accept cannot be put on screen
*do **not** credit just '… is not real'*

1

(b) (the image) needs to fall on film / sensors / LDRs / CCDs

accept just 'charged couples'
*do **not** credit '… solar cells'*
*do **not** accept virtual image cannot be stored*

1

either to cause a (chemical) reaction **or** to be digitalised *for credit response must be appropriate to camera type*

1

object (should be) on the far side of F / the focus (from the lens)

***or** … more than the focal length (away from the lens)*
allow 'beyond the focus'

or object should be more than twice the distance / 2F (from the lens) (2 marks)

***or** … more than twice the focal length (away from the lens)*
*(**2** marks)*

1

[12]

Question 8

(a) ciliary muscle

1

cornea

1

(b) (i) moved further (from his eyes)

1

(ii) rays between lens and eye converging

1

rays inside eye focus on the retina

1

(c) any **two** from:

- both use a converging lens
- image formed is real
- image is inverted
- image in eye formed on retina, image in camera formed on film / CCDs
- amount of light entering eye and camera can be controlled

2

[7]

Question 9

(a) **D**

1

(b) (i) total internal reflection shown

1

2 or 3 reflections only

1

(ii) **R U S T**

correct order

*allow **2** marks for two in correct place*

*allow **1** mark for one in correct place*

3

[6]

Question 10

4(a)	the point at which the (total) mass seems to act / appears to be concentrated	accept 'weight' for 'mass' accept the point at which gravity seems to act do **not** accept a definitive statement eg where (all) the mass is	1

4(b)	wid<u>er</u> / larg<u>er</u> base	marks are for a correct comparison	1
	low<u>er</u> centre of mass	accept lower centre of gravity / c of g	1

4(c)	<u>line of action</u> (of the weight) lies / falls inside the base	in each case the underlined term must be used correctly to gain the mark	1
	the <u>resultant moment</u> returns mixer to its original position	accept there is no <u>resultant moment</u> / <u>resultant moment</u> is zero accept resulting moment for resultant moment do **not** accept converse argument	1

Question 11

4(a)(i)	will not fall over (1) **or** centre of mass will remain above the base (1) if the monitor is given a small push (1)	accept will not easily fall over (2) (line of action of the) weight will remain above within the base accept centre of gravity / c of g / c of m / c m depends on mark above	2
4(a)(ii)	(total) clockwise moment = (total) anticlockwise moment	**or** they are equal / balanced	1
4(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

Question 12

a $2 \times 3 = 6$ s — 1

b $f = \frac{1}{T} = \frac{1}{6} = 0.167$ s — 2

c The time period would be reduced. — 1

Question 13

6(a)	38 400 Nm **or** newton metres	allow 6.4 × 6000 for **1** mark do **not** credit 'nm', 'mN' or 'metre newtons'	2 1

6(b)	16 000 (N) **or** 16 kN	allow **1** mark for 38 400 ÷ 2.4 accept their (a) ÷ 2.4 correctly calculated for **2** marks accept their (a) ÷ 2.4 for **1** mark	2

Question 14

(a)	810 000	allow 45 000 × 18 for **1** mark	2
	newton-metres / Nm		1
(b)	any **three** from:	ignore references to force throughout	3
	• their weight / mass can be altered / adjusted		
	• so that the crane remains stable	allow does not topple	
	• so that the (total) clockwise moment equals the (total) anticlockwise moment	do **not** allow just 'moments are equal'	
	• because not all containers are the same weight / mass	do **not** allow 'not all containers are the same size / volume'	
	• because not all containers will be / need to move the same distance (from the crane)		
	• to keep the centre of mass (of the upper crane and container) in/above the base of the tower		
	• so that the crane remains in equilibrium/balanced		

Question 15

(a) force

1

(b) 5

*allow **1** mark for substitution into correct equation ie* $\frac{50}{10}$

2

(c) the same as / equal to

accept =

1

[4]

Question 16

(a)	any **two** ideas: • (acceleration occurs when) the direction (of each capsule) changes • velocity has direction • acceleration is (rate of) change of velocity		2
(b)	to(wards) the centre (of the wheel)		1
(c)	centripetal	allow minor misspellings but do **not** credit a response which could be 'centrifugal'	1
(d)	the greater the radius / diameter / circumference (of the wheel) the smaller the (resultant) force (required)	accept 'the size' both parts required for the mark accept converse	1

Question 17

(i) towards Earth

for 1 mark

1

(ii) gravity

for 1 mark

1

(iii) changes direction

for 1 mark

1

(iv) polar orbit;
closer

for 1 mark each

2

(v) speed constant (1)
mass constant (1)

for 1 mark each

2

[7]

Question 18

2(a)	C → B	(1st two boxes)	allow**1** mark for either linkage in any position	1
	D → A	(end two boxes)		1

2(b)	any **two** from: • more powerful / stronger magnet • smaller gap between coil and magnet • coil with more turns / longer coil • coil with bigger area	do **not** accept just bigger magnet accept more coils do **not** accept just bigger coil do **not** accept just more wire do **not** accept shake faster do **not** accept shake for longer	2

Question 19

7(a)	any **two** from: • to (electrically) connect • stationary and moving parts • without tangling the wires	accept to complete the circuit accept to allow a current / charge to flow	2
7(b)	current (induced) is reversed / changes in direction / alternates	accept (induced) p.d. <u>across</u> the coil	1
	every half turn	do **not** accept p.d. <u>in</u> the coil	1
7(c)	by rotating / moving a magnetic field / magnet relative to a coil	accept by doing the converse / opposite	1

Question 20

(a)(i)	step-down (transformer) because fewer turns on the output/secondary (coil)	no credit for just 'step-down transformer' accept '…less turns…' do **not** credit '…fewer coils…' **or** 'the p.d. across the input / primary will be greater than the p.d. across the output / secondary'	1
(ii)	to prevent a short (circuit)(through the turns of wire or through the core	do **not** credit references to safety **or** heat (insulation)	1
(iii)	(easily) magnetised (and demagnetised)	accept '(it's) magnetic' do **not** accept 'because it's a conductor'	1

(b)	2250	correct substitution eg $\frac{150}{\text{p.d. across secondary}} = \frac{500}{7500}$ gains **1** mark **or** appropriate transformation eg (p.d. across secondary =) $\frac{\text{number of turns on secondary}}{\text{number of turns on primary}} \times$ p.d. across primary gains **1** mark	2
(c)	any **two** from: • <u>to reduce the voltage</u> / p.d. (of the domestic supply) • higher voltage difficult to insulate • higher voltage (would) result in (fatal) electric shock • domestic appliances are not designed for (very) high voltage (input) / (are designed) for 230V	**or** to reduce to 230 V allow 'to reduce to 240 V' do **not** credit 'reduce <u>current</u> to 230V' **not** just 'less dangerous' do **not** credit 'to increase efficiency' / 'to save energy' do **not** credit just 'it's safer'	2
(d)	any **two** (1) each • if the (local) power station breaks down / fails / demand / load exceeds supply • electricity / power can be switched from elsewhere in the system / from other power station(s) • electricity can be generated in places remote from customers • (in total) fewer power stations are needed • power available in rural / remote areas • National Grid allows for (better) control of supply and demand	**or** words to that effect **or** words to that effect **or** words to that effect do **not** credit just cheaper / more efficient / safer	1 1

Question 21

electromagnet becomes <u>stronger</u> (*not* becomes magnetic) iron moves left – implied OK
plunger goes up push switch goes to off or circuit broken unless plunger moves down

for 1 mark each

[4]

Question 22

(a) so the results can be compared fairly

fair test is insufficient

1

(b) **J L M**

all 3 required and no other

1

(c) (i) for a given current the number of paper clips increases by the same factor as the number of turns

1

plus a mathematical explanation using the data
eg a current of 1 A with 10 turns picks up 3 clips, a current of 1 A with 20 turns picks up 6 clips

1

(ii) 30

*allow **1** mark for showing correct use of figures eg*
20 turns × 5 = 100 turns

2

(iii) check the new data / repeat the experiment

1

to identify any anomalous results

1

then reconsider prediction / hypothesis in the light of new evidence

1

[9]