Section A

Answer **all** the questions.

1 A hovercraft moves on a cushion of air which is trapped underneath it.

The trapped air reduces friction.

(a) The hovercraft starts from rest and, as it starts, the propeller produces a forward force *F* of 28 000 N. The mass of the hovercraft is 25 000 kg.

Calculate the initial acceleration of the hovercraft. You may assume there is no friction.

acceleration = ... [2]

(b) Some time later, the hovercraft reaches a steady velocty, even though the force *F* is unchanged.

Explain, in terms of forces acting on the hovercraft why the velocity is now constant.

....

....

.... [2]

[Total: 4]

2 There is no atmosphere on the Moon.

An astronaut on the Moon drops a feather and a hammer from the same height at the same time. They both accelerate downwards at 1.6 m/s^2 and hit the ground at the same time.

(a) The weight of the hammer is much larger than that of the feather.

Explain why their accelerations are equal.

....

....

....

....

....

.... [3]

(b) The feather takes 1.5 s to fall to the ground from rest.

(i) Calculate the velocity of the feather as it hits the ground.

velocity = ... [2]

(ii) On Fig. 2.1, draw the velocity-time graph of the feather.

Mark on the vertical axis, the velocity of the feather at time t = 1.5 s.

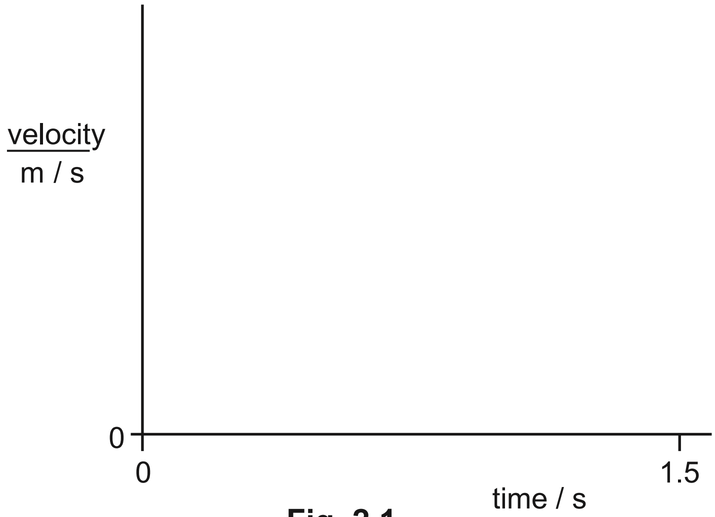


Fig. 2.1

[1]

(iii) Using the velocity-time graph in **(b)(ii)**, determine the height from which the objects are dropped.

height = ... [2]

[Total: 8]

3 Fig. 3.1 shows a chair resting on a smooth ground. A horizontal force *F* keeps the chair balanced.

C is the centre of gravity of the chair and the weight of the chair is 70 N.

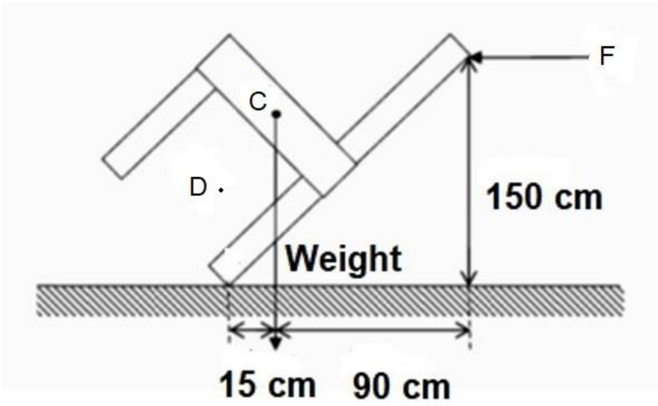


Fig. 3.1

(a) State the principle of moments.

....

....

.... [2]

(b) Calculate the force *F* applied to keep the chair balanced.

force *F* = ... [2]

(c) Small metal discs were added to the bottom of the legs of the chairs, causing the position of the centre of gravity of the chair to shift from C to D.

Explain why force *F* is no longer required to prevent the chair from toppling if the position of the centre of gravity shifts from C to D.

....

....

.... [2]

[Total: 6]

4 Fig. 4.1 shows a container of gas connected to a manometer.

The tube in the manometer has a constant cross-sectional area.

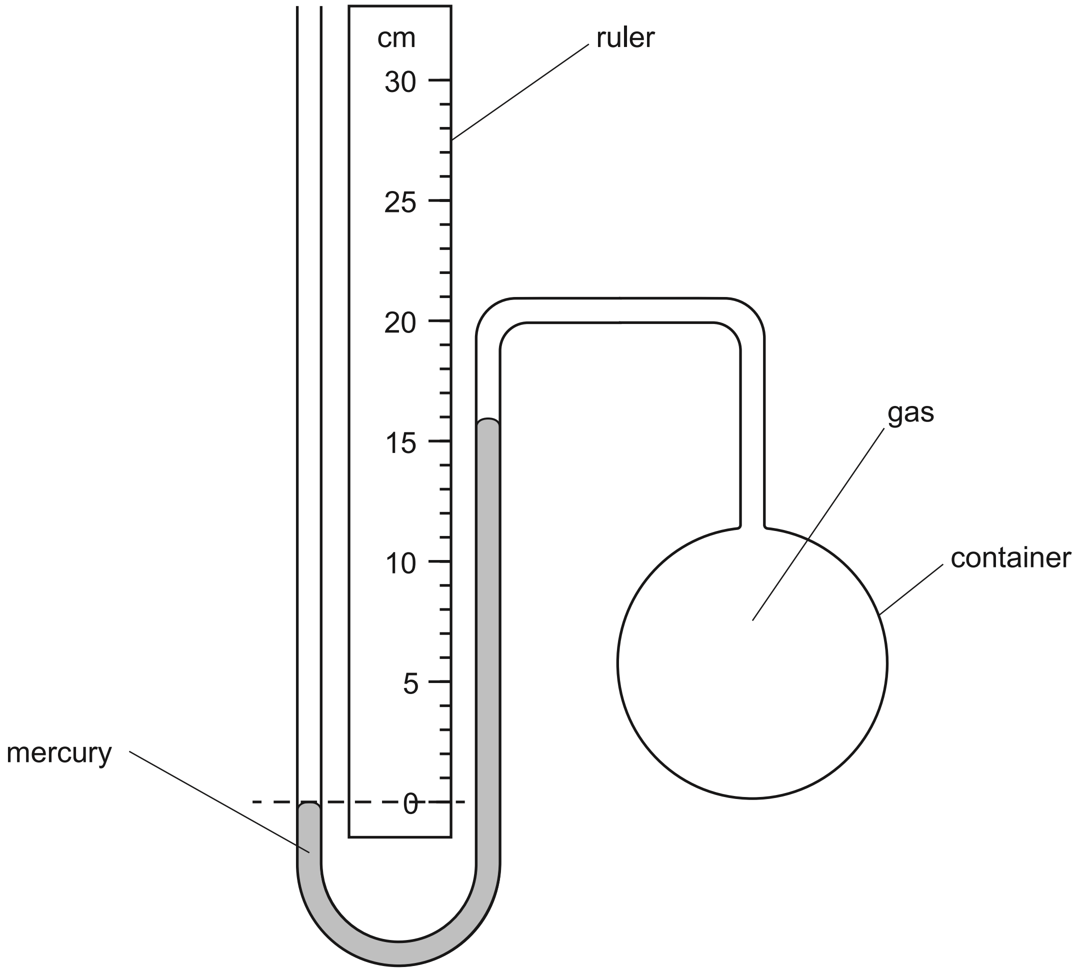


Fig. 4.1

(a) Define the term *pressure*.

....

....

.... [1]

(b) The density of mercury is 1.4×10^4 kg / m^3. The gravitational field strength g is 10 N/kg.

The pressure of the atmosphere is 1.0×10^5 Pa.

Calculate the pressure in Pa of the gas in the container.

pressure = ... [3]

(c) In Fig. 4.1, the mercury level on the left-hand side of the manometer is lower than on the right hand side.

The gas inside the container is heated. This causes the mercury levels on both sides to become the same.

(i) Mark on the ruler in Fig. 4.1 with a cross (x) when this happens.

.... [1]

(ii) Explain, in terms of the gas molecules, what causes the level of mercury to become the same.

....

....

....

.... [3]

[Total: 8]

5 Fig. 5.1 shows a square block of glass JKLM with a ray of light incident on side JK at an angle of incidence of 60º. The refractive index of glass is 1.5.

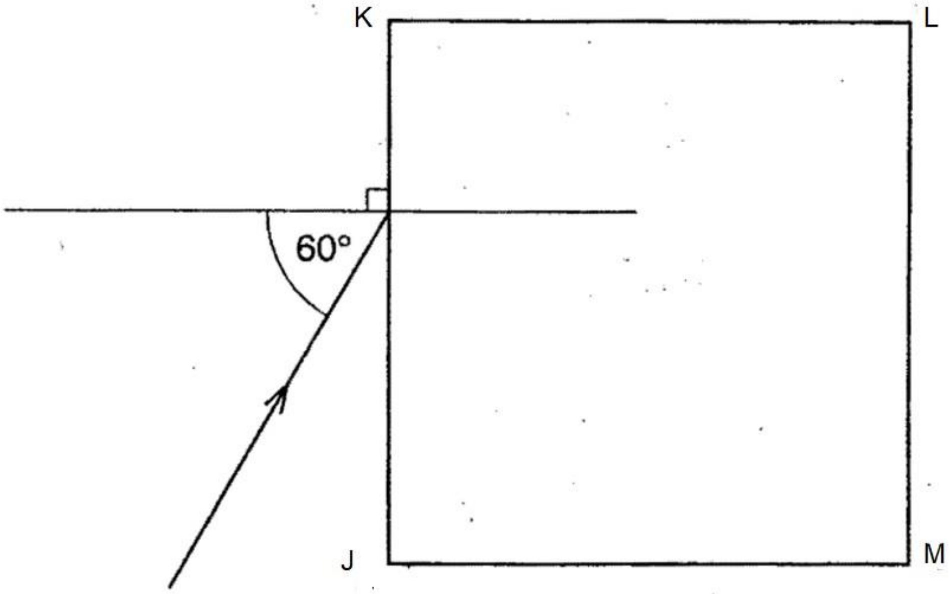


Fig. 5.1

(a) Calculate the angle of refraction of the ray.

angle of refraction = ... [2]

(b) Calculate the critical angle for a ray of light in this glass.

critical angle = ... [2]

(c) Explain why the ray shown in Fig. 5.1 cannot emerge from side KL but will emerge from side LM.

....

....

.... [2]

[Total: 6]

6 Brownian motion is the motion of tiny particles suspended in a liquid or gas. It can be seen when smoke in a sealed container is observed by using a microscope.

(a) Explain what causes Brownian motion.

....

....

....

.... [2]

(b) Suggest why Brownian motion is not observed for very large particles.

....

....

....

.... [2]

(c) Convection currents do not cause Brownian motion. Explain what is observed when the smoke particles are in a convection current.

....

.... [1]

[Total: 5]

7 Two lamps, P and Q, are connected to a 6.0 V battery and an ammeter as shown in Fig. 7.1.

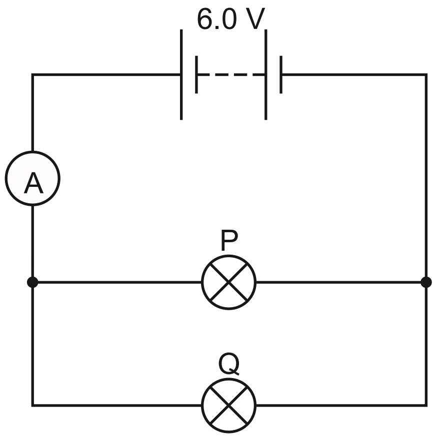


Fig. 7.1

Lamp P has a resistance of 15 Ω. The ammeter reading is 0.65 A.

(a) Calculate the current in lamp P.

current = ... [2]

(b) Calculate the resistance of lamp Q.

resistance = ... [2]

(c) The two lamps are now connected in series to the ammeter and the same battery.

Explain why the resistance of Q is smaller when connected in series.

....

.... [1]

[Total: 5]

8 Fig. 8.1 shows the fuse inside the plug of a hairdryer.

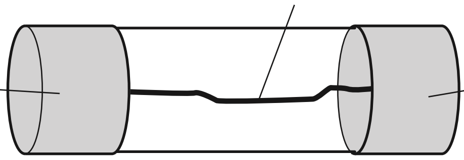


Fig. 8.1

(a) State how the fuse protects the wires in the hairdryer.

....

.... [1]

(b) The hairdryer is rated at 240 V, 1500 W. It is switched on.

(i) Calculate the current in the hairdryer.

current = ... [1]

(ii) Suggest a suitable current rating for the fuse.

current rating = ... [1]

[Total: 3]

9 A piece of plastic is held in the hand and rubbed with a cloth. Both the plastic and the cloth become charged.

(a) Describe how the plastic becomes negatively-charged and the cloth becomes positively-charged.

....

....

.... [2]

(b) Suggest why a piece of metal held in the hand does not become charged when it is rubbed with the cloth.

....

.... [1]

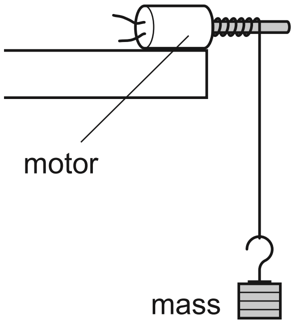
(c) An average lightning strike transfers a charge of 4.0 C and releases as much energy as a 100 W lamp switched on for 5.0×10^6 s.

Calculate the average electromotive force (e.m.f.) of a lightning strike.

e.m.f = ………………………….. [2]

[Total: 5]

10 Fig. 10.1 shows a motor lifting a mass.
Fig. 10.2 shows part of the circuit diagram of the connections to the motor.



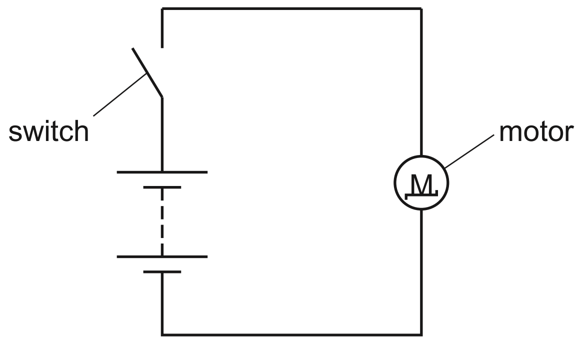


Fig. 10.1 **Fig. 10.2**

(a) The current in the motor is 1.5 A and the voltage supplied by the battery is 8.0 V.

(i) Complete the circuit diagram in Fig. 10.2 to show an ammeter and a voltmeter in the correct positions to take these measurements while the motor is working. [2]

(ii) The motor takes 4.0 s to lift the mass.

Calculate the energy transferred to the motor in this time.

energy = ... [2]

(iii) The motor lifts the 150 g mass through a height of 80 cm in the 4.0 s.

Calculate the increase in energy in the gravitational potential store of the mass.

The gravitational field strength *g* = 10 N/kg.

energy in the gravitational potential store = ... [2]

(b) Fig. 10.3 shows the structure of the motor in Fig. 10.2

When the mass reaches the top of its motion, the switch is opened.
This disconnects the battery and causes the mass to fall. The coil turns as the mass falls.

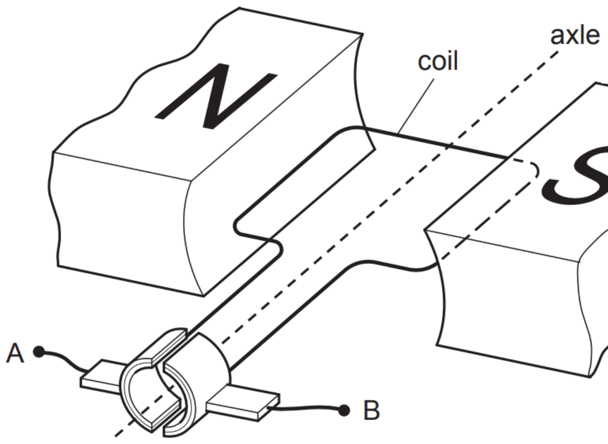


Fig. 10.3

As the coil turns, a small voltage is produced.

(i) Explain why a voltage is produced as the coil turns.

....

....

.... [2]

(ii) As the mass falls, a student connects a wire between the points A and B shown in Fig. 10.3.

He notices that the mass takes a longer time to fall when the wire is connected.

Suggest why the mass takes longer to fall.

....

....

....

....

....[2]

[Total :10]

11 Fig. 11.1 shows two types of filament lamps, one with its filament wire coiled and the other with its filament wire uncoiled.

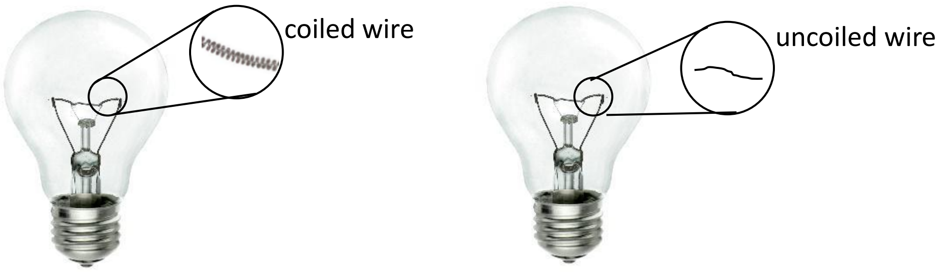


Fig. 11.1

Table 11.2 below summarises the design and characteristics of four filament lamps A, B, C, D.

Table 11.2

lamp	characteristics of filament wire					
	material	coiled or uncoiled	cross-sectional area / m^2	specific heat capacity / J/(kg°C)	resistance per unit length Ω/m	temperature reached at maximum brightness / °C
A	tungsten	coiled	3.1×10^{-6}	133	1.8×10^{-2}	3420
B		uncoiled				
C	copper	coiled	6.2×10^{-6}	378	2.8×10^{-3}	1085
D		uncoiled				

(a) State and explain, using the values in Table 11.2, which of the lamps will give off the brightest light.

....

....

....

....

....[3]

(b) Explain, using energy stores and transfers, how the principle of conservation of energy applies to the lamp transferring its energy to the surroundings.

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………[3]

(c) A filament lamp has a power rating of 0.050 kW and is connected to a 240 V power supply. It reaches its maximum brightness in 0.18 s.

Assuming no transfer of energy to the surroundings and that the room temperature is 30ºC,

(i) calculate the total thermal energy produced by the lamp in 0.18 s, and

total thermal energy = …………………………….[2]

(ii) using your answer in **c(i)**, determine the minimum mass of the filament wire when copper is used.

mass = …………………………..…[2]

[Total: 10]

Section B

Answer **one** question from this section.

12(a) Fig. 12.1 shows a simple relay used to switch a mains electric motor on and off.

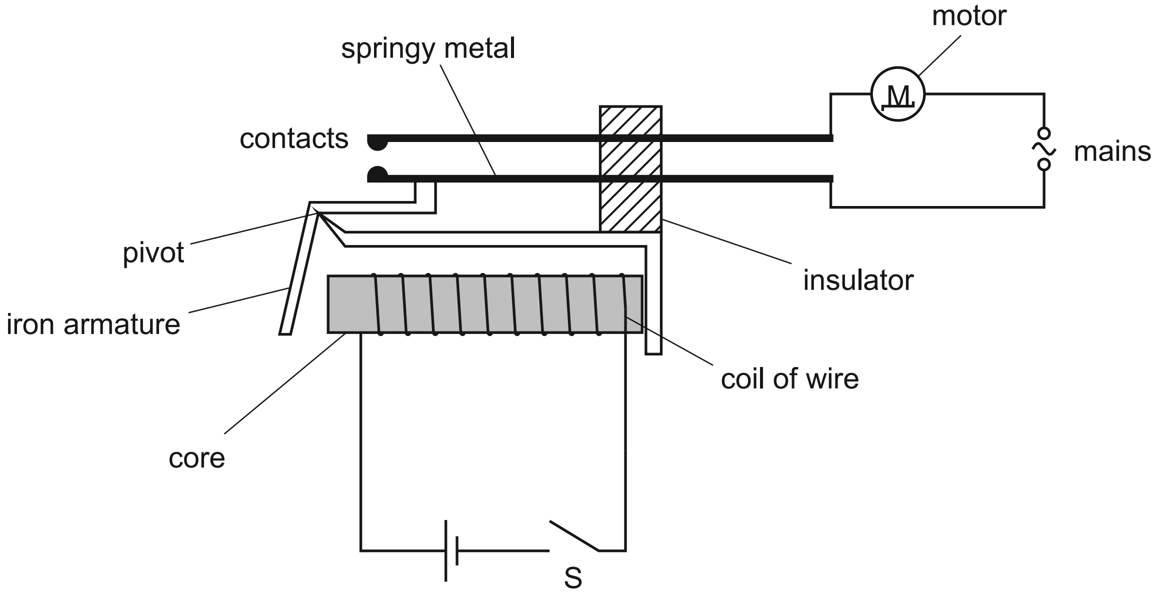


Fig. 12.1

(i) Explain why the motor switches on when switch S is closed.

....

....

....

....[3]

(ii) Explain why the core is made of iron rather than steel.

....

....

.... [2]

(b) Fig. 12.2 shows the coil of wire wrapped around a cardboard tube with no core.

There is an electric current in the wire in the direction shown by the arrows.

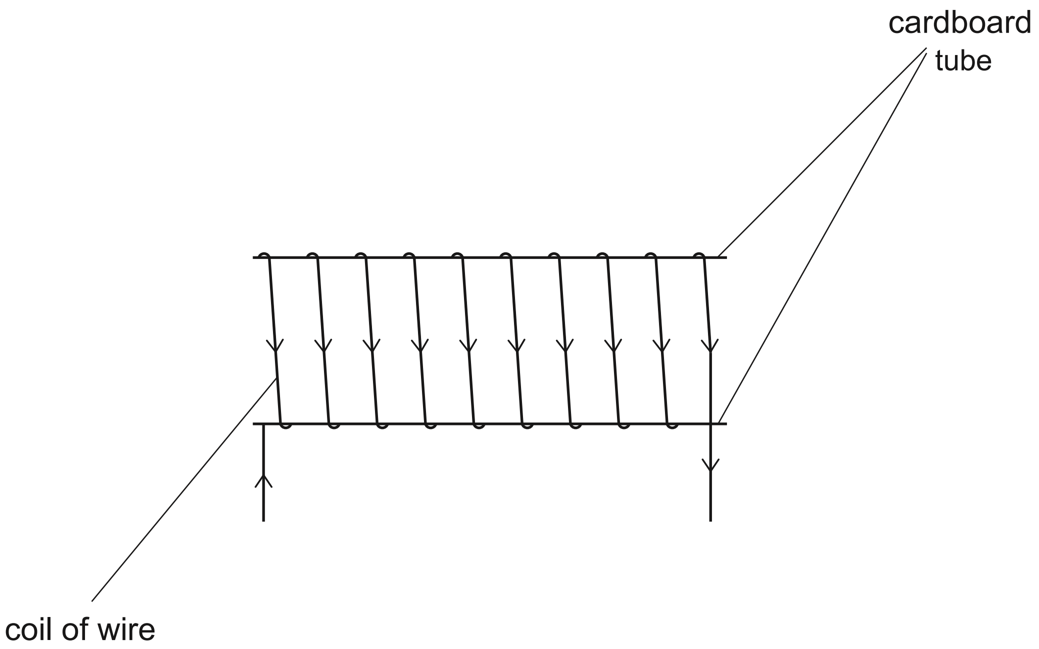


Fig. 12.2

On Fig. 12.2, mark the N-pole of the coil. [1]

(c) The supply of current to the coil is removed.

The coil is also removed and reused to make a transformer with an alternating current supply of 3.0 V as shown in Fig. 12.3

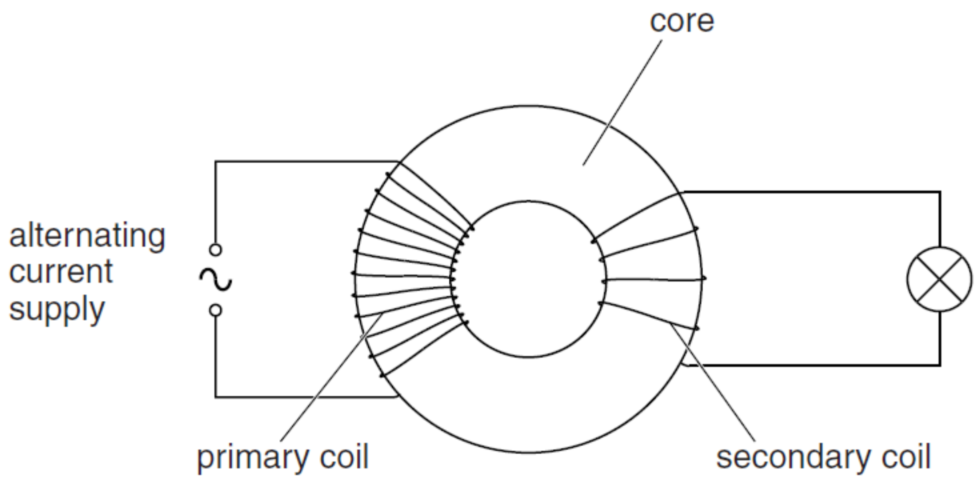


Fig. 12.3

(i) Explain how the alternating current in the primary coil causes the lamp to light.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………[2]

(ii) The transformer has 1200 turns on the primary coil and 400 turns on the secondary coil.

Assume that the transformer is ideal and does not have any power loss.

Given that the current in the primary coil is 0.25 A, calculate the current in the lamp.

.

current = …………….. [2]

[Total: 10]

13 Ultrasound and X-rays are both used in medical imaging.

(a) **(i)** Define *ultrasound*.

....

.... [1]

(ii) Describe what happens to ultrasound waves as they travel across two different materials.

....

.... [1]

(iii) To produce the image of an unborn child, an ultrasound emitter and receiver are placed close to each other on the mother's skin.

Fig. 13.1 shows pulses detected by the receiver.

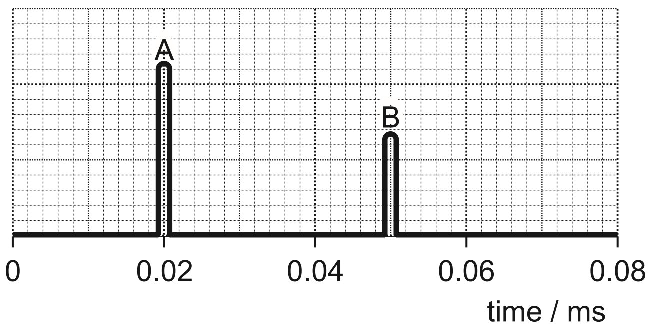


Fig. 13.1

Pulse A is the emitted pulse and pulse B is the first pulse that returns from the unborn child.

The average speed of ultrasound in human tissue is 1500 m/s.

Calculate the distance between the emitter and the child.

distance = ……………………………………….[3]

(ii) Describe how ultrasound is transmitted from the emitter to the human tissue.

....

....

.... [2]

(b) Fig. 13.2 shows an X-ray image of a hand. An X-ray detector is placed just below the hand. An image of the bones and human tissue around the bones is formed on a screen by the detector.

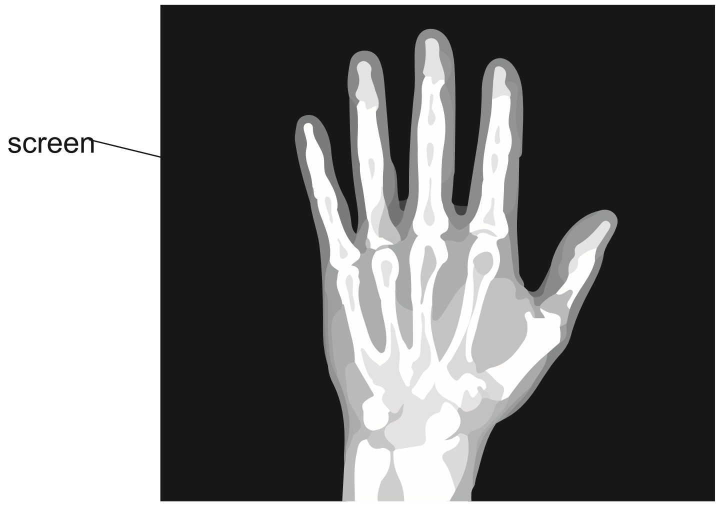


Fig. 13.2

(i) State a characteristic of X-ray.

....[1]

(ii) The wavelength of the X-rays used is 2.0×10^{-9} m.

The speed of electromagnetic waves is 3.0×10^{8} m/s.

Calculate the frequency of the X-rays.

frequency = ……………….. [2]

[Total: 10]