Class	Index Number	Name

BUKIT MERAH SECONDARY SCHOOL

PRELIMINARY EXAMINATION 2024
SECONDARY 4 EXPRESS

PHYSICS **6091/02**

Paper 2 Theory **19 August 2024**

1 hour 45 minutes

Candidates answer on the Question Paper.
No additional material is required.

READ THESE INSTRUCTIONS FIRST

Write your class, index number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Section A
Answer **all** questions.

Section B
Answer **one** question.

Candidates are reminded that all quantitative answers should include appropriate units.
The use of an approved scientific calculator is expected, where appropriate.
Candidates are advised to show all their working in a clear and orderly manner, as more marks are awarded for sound use of Physics than for correct answers.

The number of marks is given in brackets [ ] at the end of each question or part question.

Section A (70 marks)

Answer **all** the questions in this section.

1 Fig. 1.1 shows a bird cage hanging on a uniform wooden pole of length 1.8 m and mass 10 kg.

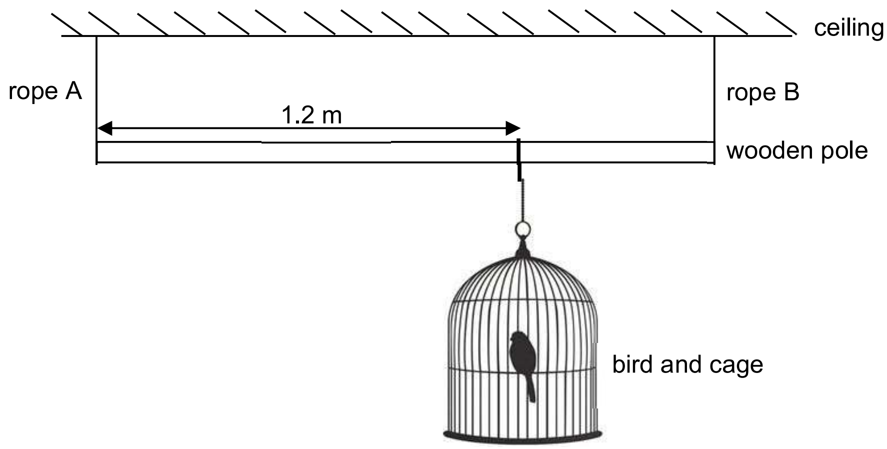

Fig. 1.1

The pole is kept horizontal by two ropes, A and B, each tied at the ends of the pole.
The bird and the cage have a total mass of 6.0 kg and is suspended 1.2 m away from rope A.
The gravitational field strength *g* is 10 N/kg.

(a) Using the principle of moments or otherwise, calculate the tension in rope A and B.

tension is rope A = ………………………….

tension is rope B = …………………………. [3]

(b) The bird keeper wants to suspend another bird cage of weight 30 N on the pole without increasing the tension in rope B as he is afraid rope B will snap.

Suggest and explain where he should suspend this second bird cage.

……………………………………………………………………………………………………..

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

[Total:5]

2 A set-up consists of a syringe and a manometer connected to each end of a pipe can be used to detect leaks in the pipe.

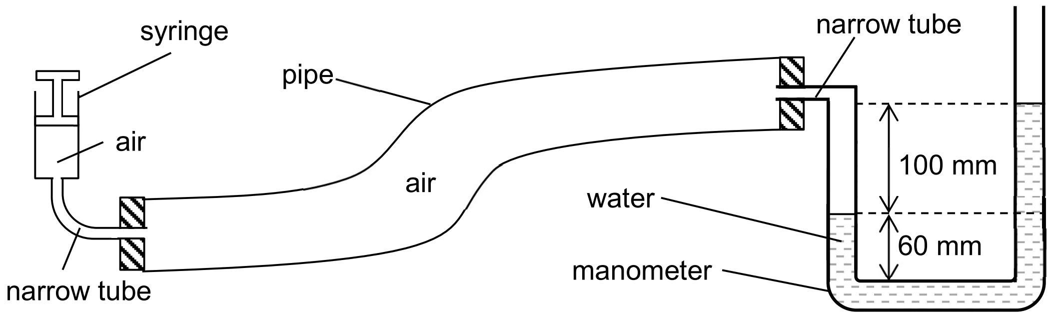

Fig. 2.1

(a) Fig. 2.1 shows the levels of water on each side of the manometer after the piston is pushed down and left down and the air inside the syringe is pushed into the pipe.

The atmospheric pressure is 100 kPa. The gravitational field strength is 10 N/kg and the density of water in the manometer is 1000 kg/m^3.

Calculate the air pressure inside the pipe.

air pressure in pipe = …………………………….. [2]

(b) If the pipe leaks very slowly, state what happens to the levels of water on each side of the manometer.

You may add to Fig. 2.1 if it helps to explain your answer.

……………………………………………………………………………………………………..

……………………………………………………………………………………………………[1]

(c) Using ideas about molecules and pressure, explain you answer in **(b)**.

………

………

………

……… [2]

(d) Other than the toxicity of mercury, explain why mercury is not a suitable liquid to use in the manometer in this situation.

………

……… [1]

[Total:6]

3 The main parts of an electric grill are shown in Fig. 3.1. The heating element will glow red hot.

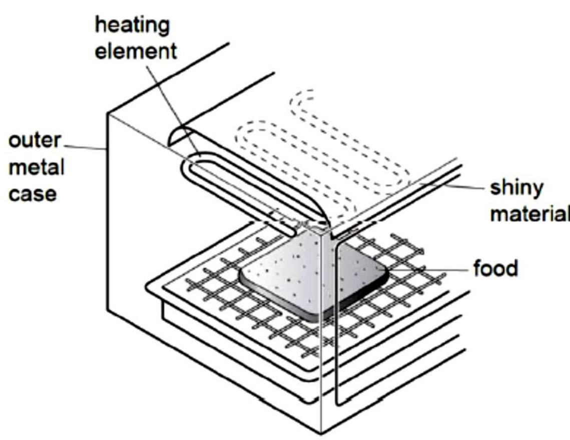

Fig. 3.1

(a) Name the main process of energy transfer responsible for cooking the food.

……… [1]

(b) A layer of shiny material is placed between the heating element and the top of the metal case of the grill.

Explain one way in which it improves the function or design of the electric grill.

………

……… [1]

[Total:2]

4 A student poured 0.25 kg of hot tea into a container. At time t = 0 min, he placed a temperature sensor into the hot tea and started measuring the temperature of the tea. After a certain time, ice cubes were added to the hot tea. Fig. 4.1 shows the temperature-time graph obtained.

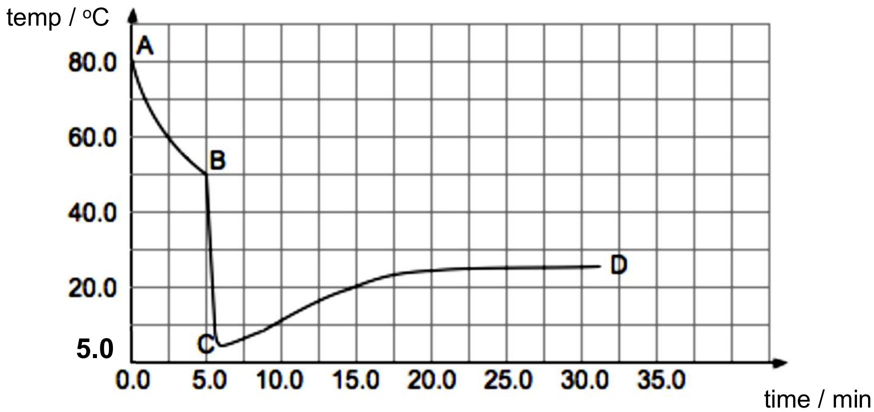

Fig. 4.1

The following information is provided.

specific latent heat of fusion of ice	336 kJ/kg
specific latent heat of vaporisation of water or tea	2260 kJ/kg
specific heat capacity of ice	2100 J/(kgK)
specific heat capacity of water or tea	4200 J/(kgK)

Assume that there is no transfer of energy to the internal store of the surroundings when ice is added and the initial temperature of the ice-cubes is 0 °C.

(a) State the time at which the student added the ice cubes into the hot tea.

………. [1]

(b) Calculate the loss of energy from the internal store of the hot tea from B to C.

loss of energy = …………………………… [1]

(c) Calculate the mass of the ice cubes added into the hot tea.

Mass of ice cubes = …………………………… [2]

(d) Explain in terms of molecules, how evaporation helps the hot tea to cool down.

……

……

……

…… [2]

[Total:6]

5 Fig. 5.1 shows the path of ray X as it passes through a thin converging lens AB. An image is formed at Y.

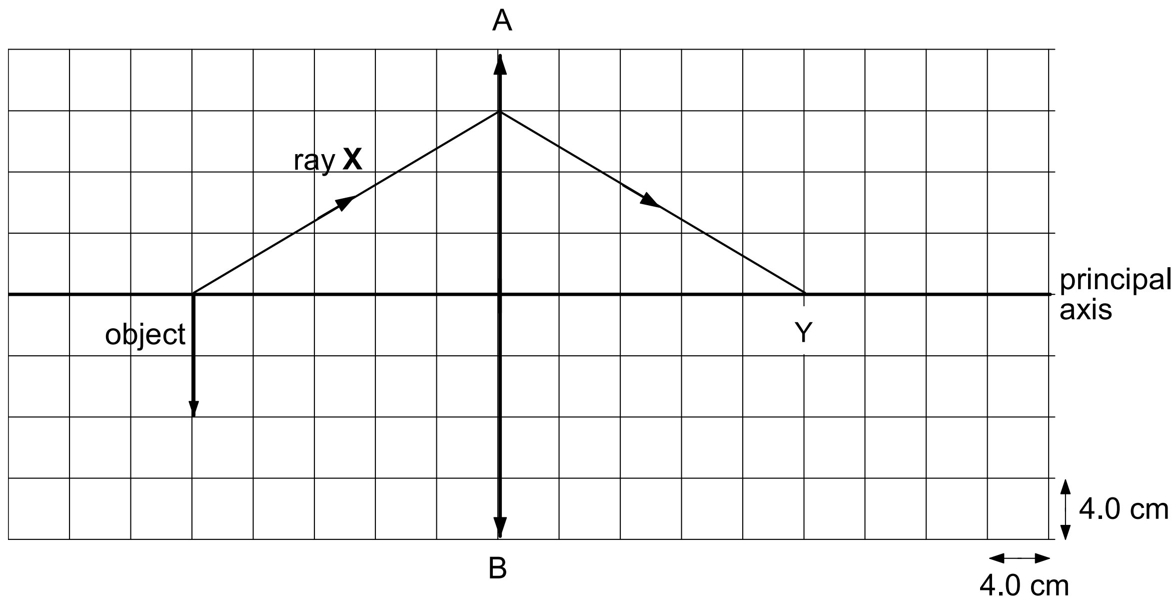

Fig. 5.1

(a) Determine the focal length of the lens AB.

focal length = ………………………………. [1]

(b) On Fig. 5.1, draw rays to show how the image is formed. Label the image, I. [2]

(c) The image formed is real.

State what is meant by *real*.

………

……………………………………………………………………………………………………… [1]

(d) State the name of a device that uses a converging lens to form an image as found in part **(b)**.

……………………………………………………………………………………………………… [1]

[Total:5]

6 An engineer designs an ultrasound device that can be used to monitor the thickness of pipes as shown in Fig. 6.1.

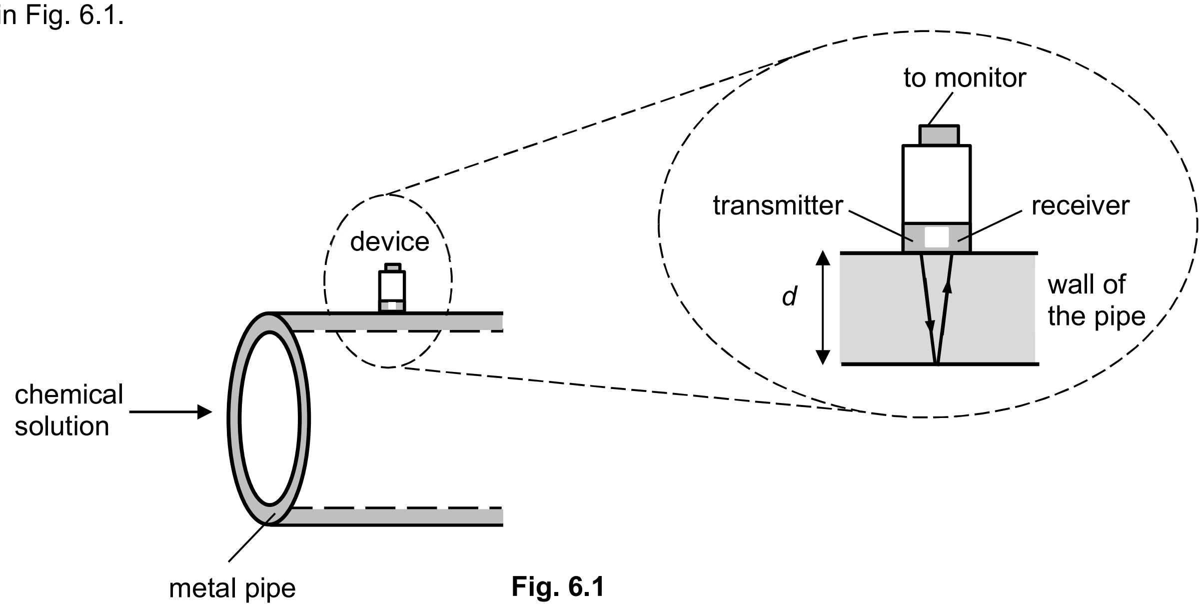

Fig. 6.1

The device emits an ultrasound pulse of frequency 4.0 x 10^6 Hz. The pulse travels through the wall of the metal pipe and is reflected by the inner wall back to the device. The returning pulse is picked up by the receiver. Both the transmitter and the receiver are connected to a monitor.

The metal pipe is made of steel. Table 6.1 shows the speed of sound in different media.

Table 6.1

medium	speed of sound / ms^{-1}
air	340
glass	4 000
steel	6 100
water	1 400

(a) Determine the wavelength of the ultrasound pulse in the wall of the pipe.

wavelength = …………………….. [1]

(b) At one point of time, the series of compressions and rarefactions of the ultrasound waves in the wall of the pipe is as shown in Fig. 6.2. Points A, B, C and D are at the centres of regions of compression.

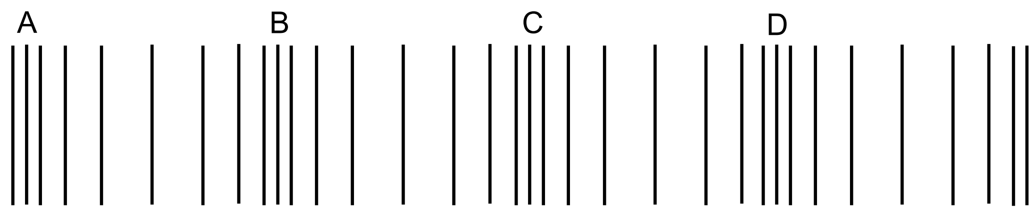

Fig. 6.2 (not drawn to scale)

Determine the distance between points A and D.

distance = ………………………. [1]

(c) The thickness of the pipe is 4.0 mm.

Calculate the time interval, in μs, between the emitted pulse and the reflected pulse.

time = ………………………. [2]

(d) Fig. 6.3 shows the emitted pulse on the monitor.

On Fig. 6.3, draw the reflected pulse. [1]

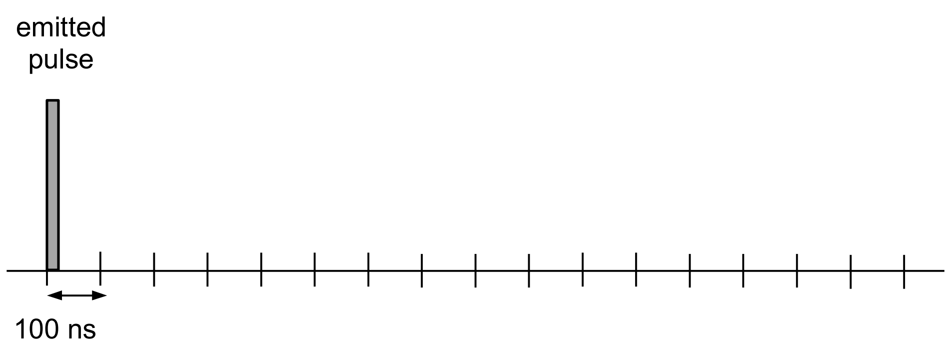

Fig. 6.3

[Total:5]

7 Fig. 7.1 shows an uncharged thick metal can that is connected to a galvanometer.

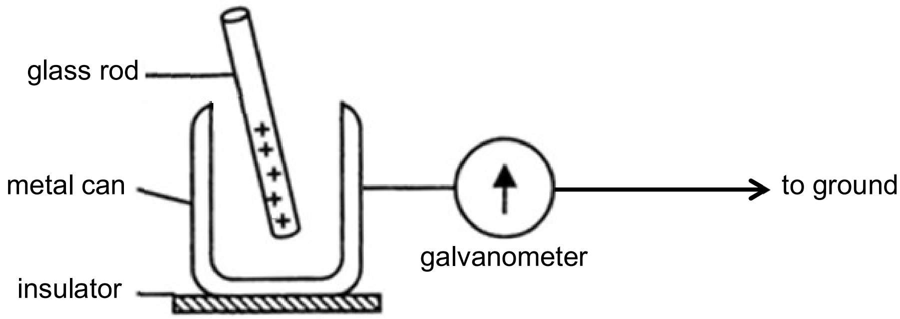

Fig. 7.1

(a) When a positively charged rod is lowered into and not touching the metal can, it is observed that the galvanometer shows a deflection but returns to zero soon after.

Explain the observation.

....

....

....

.... [3]

(b) Describe one way to change the direction of the detection of the galvanometer.

....

.... [1]

[Total:4]

8 Fig. 8.1 shows an electrical circuit containing three resistors. A 50.0 cm long resistance wire of resistance 10.0 Ω per metre is added across points XY.

A jockey J is placed on the 40.0 cm mark of the resistance wire and the other end is connected to a voltmeter. Switches S_1 and S_2 are used to control the current in the circuit.

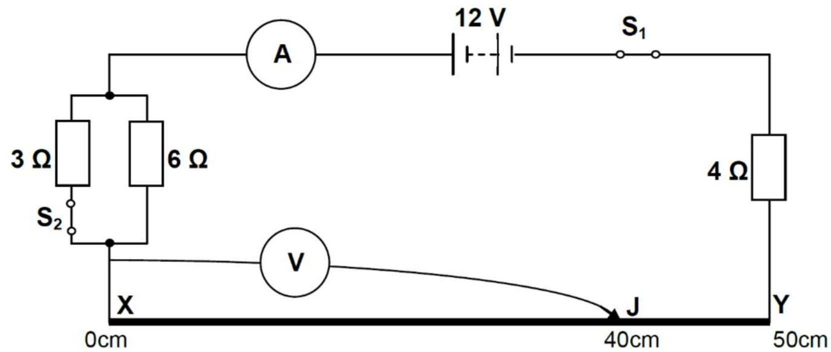

Fig. 8.1

(a) When switch S_1 is opened, the ammeter reading is zero.

State the value of the potential difference across S_1.

…………………………………………………………………………………………………... [1]

(b) When S_1 is closed and S_2 is opened, determine the

(i) ammeter reading and

ammeter reading = ………………….……[2]

(ii) voltmeter reading

voltmeter reading = ………………….……[1]

(c) Without further calculation, explain whether there are changes in both meters when switches S_1 and S_2 are closed as compared to **(b).**

………..

………..

………..

……… [2]

(d) State the changes to the voltmeter reading when the jockey J is moved towards X.

……..... [1]

[Total:7]

9 Fig. 9.1 shows a reed switch made of two soft iron connected in series with a cell with a warning light. The other circuit in Fig. 9.1 consists of a thermistor, a cell and a coil wound round the reed switch.

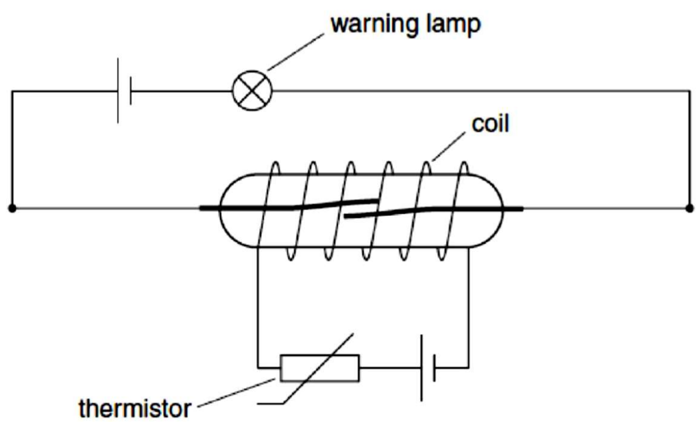

Fig. 9.1

(a) Mark, on Fig. 9.1, the magnetic poles produced at each end of both pieces of soft iron. [1]

(b) Explain how this arrangement can be used to warn the farmers when the temperature in a greenhouse is too high.

………....

…….

…….

………. [2]

(c) Explain the effectiveness of this device if the reed switch is replaced with steel rods.

…….

………...[1]

[Total:4]

10 Fig. 10.1 shows a mobile phone and a wireless charger. The mobile phone can be charged wirelessly by placing it on the charger unit without any metal contacts to connect the phone to the charger.

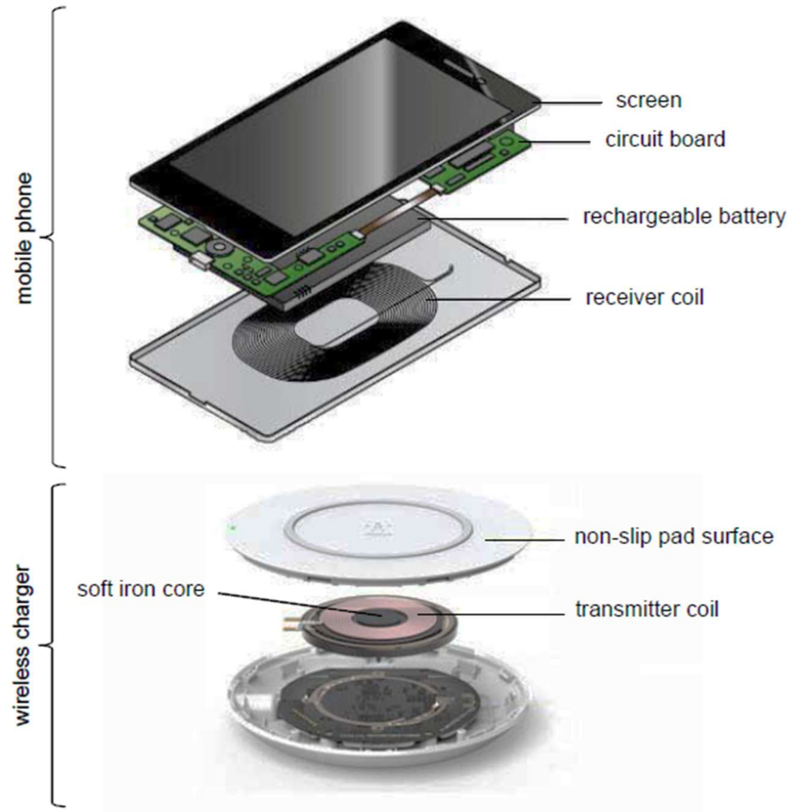

Fig. 10.1

The bottom of the mobile phone contains a receiver coil. The phone contains a rechargeable battery rated at 3.7 V. In the wireless charger, the transmitter coil is connected to the mains a.c. supply.

(a) Explain how the presence of an a.c. current in the transmitter coil causes a current to flow in the receiver coil even though they are not in electrical contact.

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

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

(b) Explain how the presence of the soft iron core in the transmitter coil improves the efficiency of charging the battery of the mobile phone.

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

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

(c) The mains is rated at 230 V a.c. and the rating of the rechargeable battery in the mobile phone is 3.7 V.

Calculate the turns ratio of the receiver coil to that in the transmitter coil.

turns ratio = ………………………………… [1]

[Total:6]

11 Fig. 11.1 shows a multi-mode optical fibre with glass of uniform refractive index.

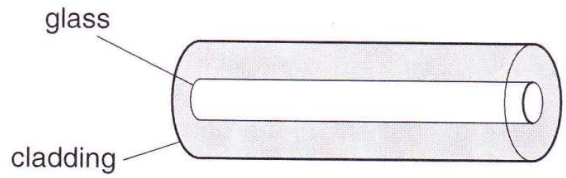

Fig. 11.1

Fig. 11.2 shows three rays of light entering the fibre from air. Each of these rays follows one of the three possible paths through the fibre.

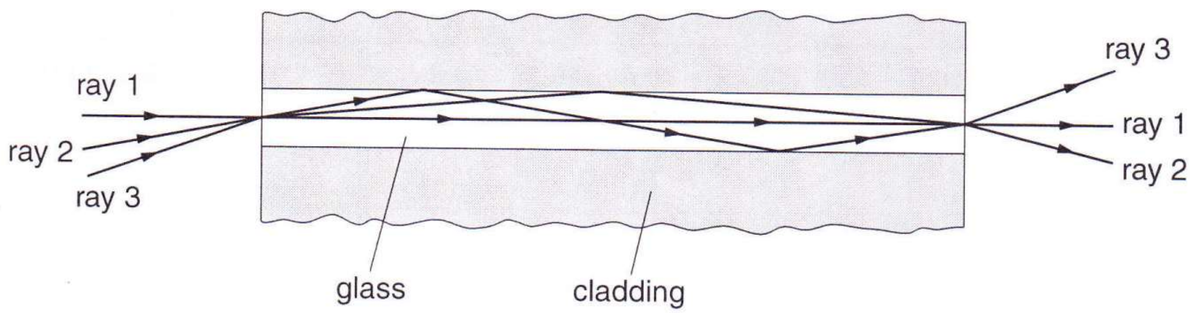

Fig. 11.2 (not to scale)

The three rays travel different distances and take different times to pass through the fibre.

Table 11.1 gives information about the three rays and their paths in two cables of length 1.0 km and 2.0 km respectively.

Table 11.1

	angle of incidence on entry /°	angle of refraction on entry /°	distance covered in 1km cable /m	time spent in 1km cable / μs	distance covered in 2km cable /m	time spent in 2km cable / μs
ray 1	0	0	1000	5.0	2000	10.0
ray 2	20	13	1027	5.1	2054	10.3
ray 3	35	*X*	1082	5.4	2164	10.8

(a) Using data for ray 1 from Table 11.1, calculate the refractive index of the glass.

The speed of light is 3.0×10^8 m/s.

refractive index = ………………………… [2]

(b) Calculate the angle of refraction *X* for ray 3.

angle = ………………………… [2]

(c) At time t = 0, a single pulse of light enters the optical fibre of length 2 km. The pulse lasts 0.1 μs. Fig. 11.3 shows the brightness of the pulses of light that leaves the fibre.

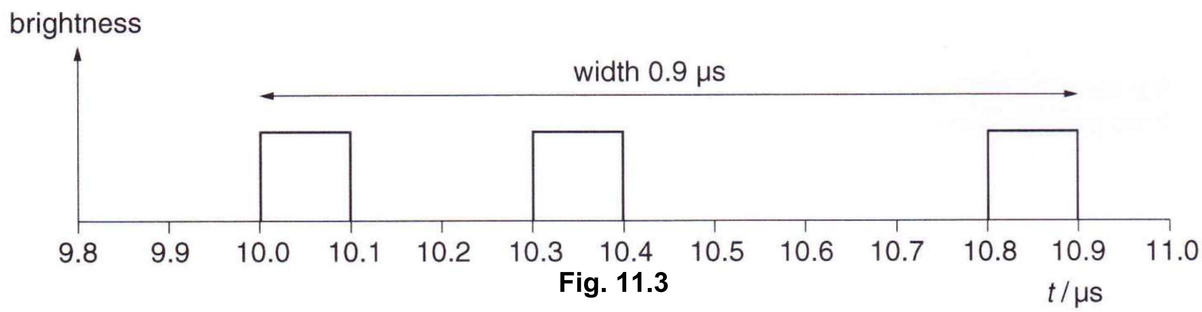

Fig. 11.3

(i) Using data from Table 11.1, explain Fig. 11.3.

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

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

……………………………………………………………………………………………………[1]

(ii) At t = 0, a single pulse of light enters the optical fibre of length 1 km. This pulse also lasts 0.1 μs.

On Fig. 11.4, draw the pulses of light that leaves the fibre. [2]

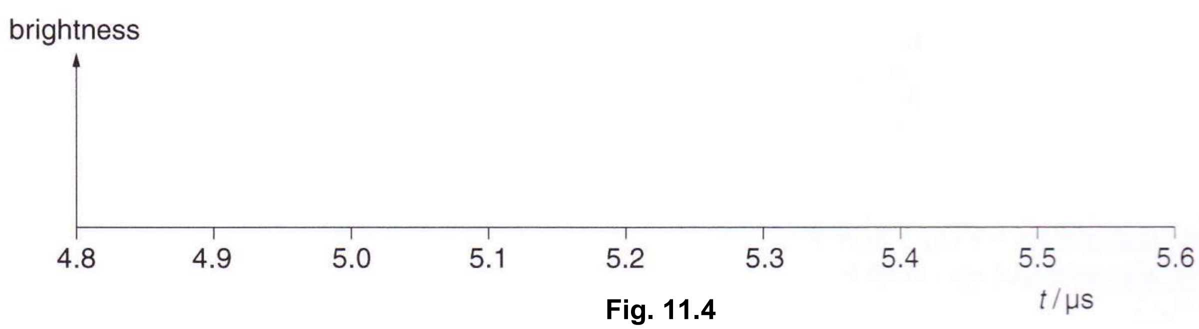

Fig. 11.4

(iii) Fig. 11.3 shows that a pulse of light, lasting 0.1 μs when it enters the 2 km optical fibre, becomes three pulses lasting in total 0.9 μs when it leaves.

In a telephone conversation, a series of pulses is sent along the optical fibre. It is important that no light from one pulse overlaps light from the next pulse. A second pulse of 0.1 μs must enter the fibre at least 0.9 μs after the first.

Estimate the maximum number of pulses of light that can enter the 2 km optical fibre in one second.

number of pulses per second = ………………………… [2]

(iv) Explain why this type of optical fibre is **not** used to transmit data at high rates over very long distances?

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

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

……………………………………………………………………………………………………[1]

[Total:10]

12 A child on a sledge slides down a steep hill and then travels in a straight line up an ice-covered slope, as illustrated in Fig. 12.1.

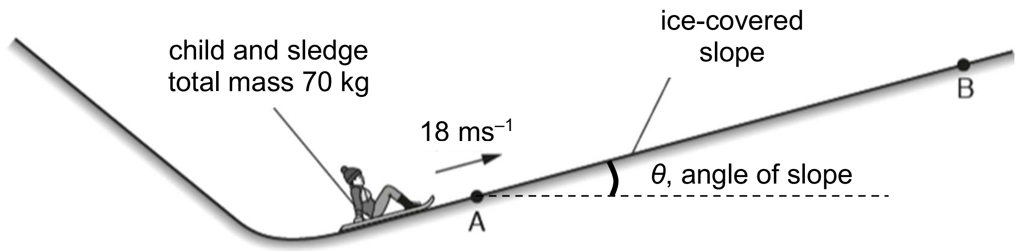

Fig. 12.1 (not to scale)

The sledge passes point A with a speed of 18 m/s at time t = 0 and then comes to rest at point B. The child applies a brake to the sledge at point B. The brake does not keep the sledge stationary and it immediately slides back down the slope towards A.

The variation of velocity v of the sledge from t = 0 to t = 24 s is shown in Fig. 12.2.

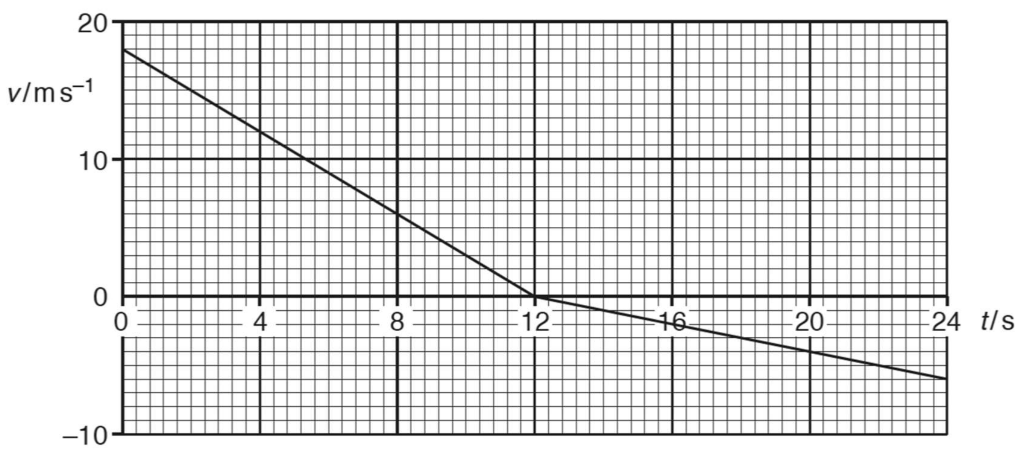

Fig. 12.2

(a) Calculate the displacement of the sledge up the slope from point A at t = 24 s.

displacement = ... [2]

(b) Fig. 12.2 shows that the portion of graph between t = 0 to t = 12 s is different from that between t = 12 to t = 24 s.

State the two ways in which they are different and hence explain how that shows the difference in motions of the sledge in the two periods.

……….....

……….

……….

……….

……….

……….[2]

(c) State and explain whether the forces acting on the sledge are balanced at t = 12 s.

……….

……….[1]

(d) Show that the magnitude of the resultant force acting on the sledge is 35 N as it moves from B back towards A.

[2]

(e) The frictional force is between the sledge and the slope as it moves between A and B is 25 N.

(i) Calculate the total work done against friction as the sledge moves from A to B.

work done = ………………………… [1]

(ii) Hence, with reference to Fig. 12.2, determine θ the angle of the slope to 0.1 degree accuracy.

θ = ……………………..[2]

[Total:10]

Section B

Answer **one** question from this section.

13 **(a)** Fig. 13.1 shows a wire wound around a soft iron core forming a solenoid. There is a gap in the core. The solenoid is connected in series with a 12 V battery and a variable resistor.

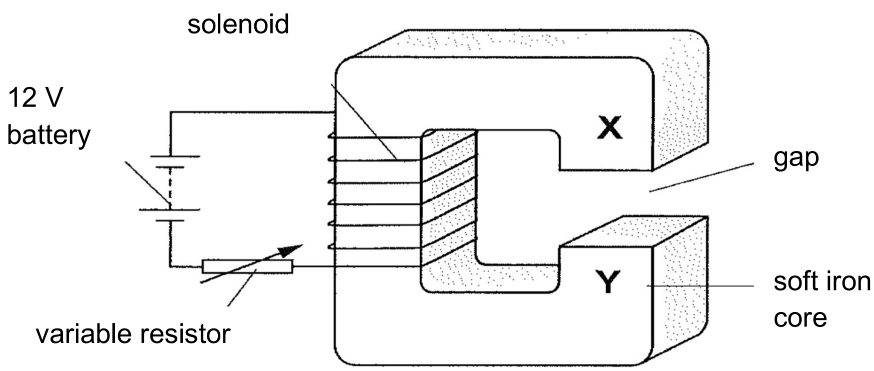

Fig. 13.1

(i) The current in the solenoid magnetises the soft iron core.

State one change that can be made to increase the strength of the magnetic field.

……………………………………………………………………………………………………… [1]

(ii) Fig. 13.2 shows a horizontal current-carrying wire PQ in the gap.

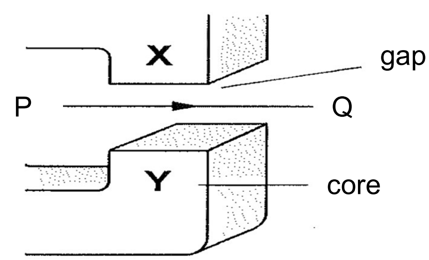

Fig. 13.2

The current in PQ flows from left to right. Describe and explain the effect of the force exerted on PQ.

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

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

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

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

(iii) State and explain the effect on PQ if the 12 V battery is replaced with a 12 V alternating supply source.

……………………………………………………………………………………………………........

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

(b) In a separate circuit shown in Fig. 13.3, a high voltage d.c. supply is connected to a fixed resistor and a light-dependent resistor (LDR). An ammeter is used to measure the current in the circuit; the inner component of the ammeter is as shown in Fig. 13.4.

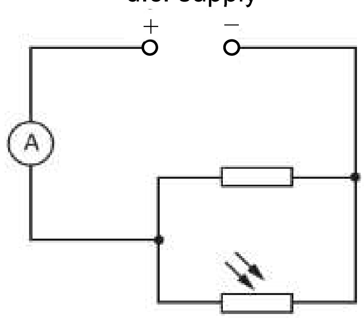

Fig. 13.3

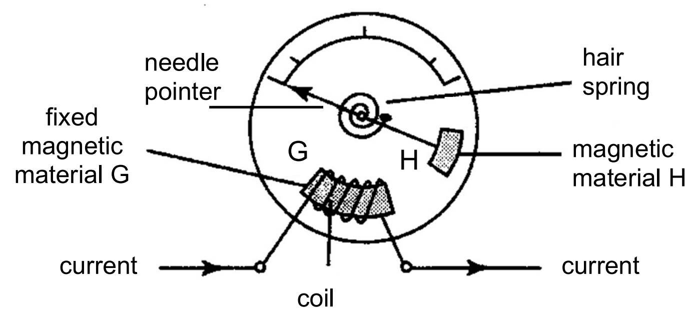

Fig. 13.4

Describe and explain how the pointer of the ammeter is deflected when a steady current flows through the ammeter, and how the deflection changes as the light intensity around the LDR gradually increases.

……………………………………………………………………………………………………................

……………………………………………………………………………………………………................

……………………………………………………………………………………………………................

……………………………………………………………………………………………………................

………[4]

[Total:10]

14 An electric heater operating from a 240 V mains is connected to a 3-pin socket by a 3-pin plug containing a fuse. The circuit of the electric heater consists of

- Two heating elements P and Q connected in parallel, rated at 1.0 kW 240 V and 1.5 kW 240 V respectively,
- Two switches X and Y, which are connected such that neither element heats up unless switch X is on. When switch Y is off, only element P heats up; when switch Y is on, both elements heat up; and
- A 25 W indicator lamp, which is connected such that it lights up whenever the heater is plugged in, even when switches X and Y are off.

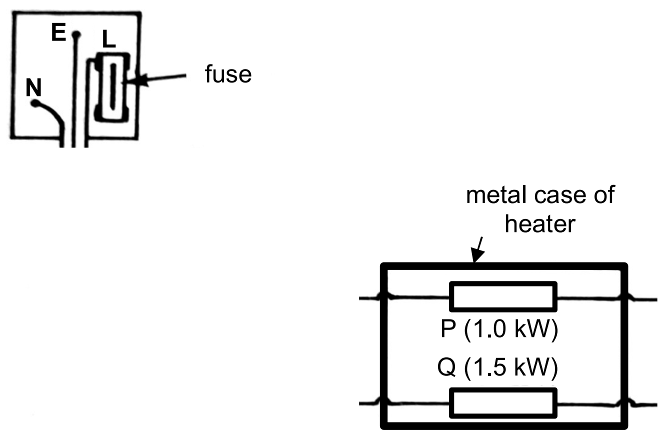

Fig. 14.1

(a) Fig. 14.1 shows an incomplete diagram of the electric heater circuit. The ends of elements P and Q are shown sticking out of the metal case.

Using appropriate symbols, complete Fig. 14.1 showing the correct connections from the fused plug to the heater. The positions of the lamp and the two switches X and Y are to be clearly indicated and labelled. [2]

(b) Calculate

(i) The current when only the lamp is on,

current = ………………………….. [1]

(ii) The energy consumed when the lamp and the heaters are turned on for 8.0 hours. Express your answer in kWh.

energy consumed = ………………………….. [2]

(c) The insulation of the three wires, live, neutral and earth becomes damaged and bare metal wires show.

Five possible events can occur.

- A person touches the earth wire.
- A person touches the neutral wire.
- A person touches the live wire.
- The live wire touches the neutral wire.
- The live wire touches the earth wire.

State and explain how many of these five events will cause the fuse to blow.

……………………………………………………………………………………………………….......

……………………………………………………………………………………………………….......

……………………………………………………………………………………………………….......

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

(d) Explain the purpose of including the earth wire in the wirings of the heater.

……………………………………………………………………………………………………….......

……………………………………………………………………………………………………….......

……………………………………………………………………………………………………….......

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

[Total:10]