HUA YI SECONDARY SCHOOL
PRELIMINARY EXAM 2024

4-G3

NAME			
CLASS		INDEX NUMBER	

PHYSICS **6091/02**

PAPER 2

21 August 2024

1 hour 45 minutes

Additional Materials: Nil

READ THESE INSTRUCTIONS FIRST

Write your Name, Class, and Index Number 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, highlighters, glue, or correction fluid.

Section A
Answer **all** questions.
Write your answers in the spaces provided.

Section B
Answer **one** question.
Write your answers in the spaces provided.

Section A	**70**
Section B	
	10
Total	**80**

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.

This document consists of **21** printed pages and **1** blank page.

Setter: Mrs Lim Kai Xin

Section A [70 marks]

Answer **all** the questions in the spaces provided.

1 Fig. 1.1 shows a child sliding down a slope on a snow sledge.

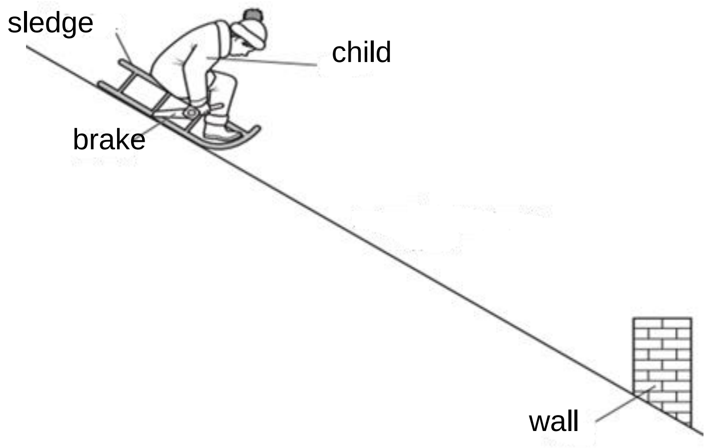

Fig.1.1

At time t = 0, the child and the sledge begin to move down the hill. When the child sees a wall ahead, he applies the brake and eventually comes to a stop.
Fig. 1.2 is the velocity time graph for the journey.

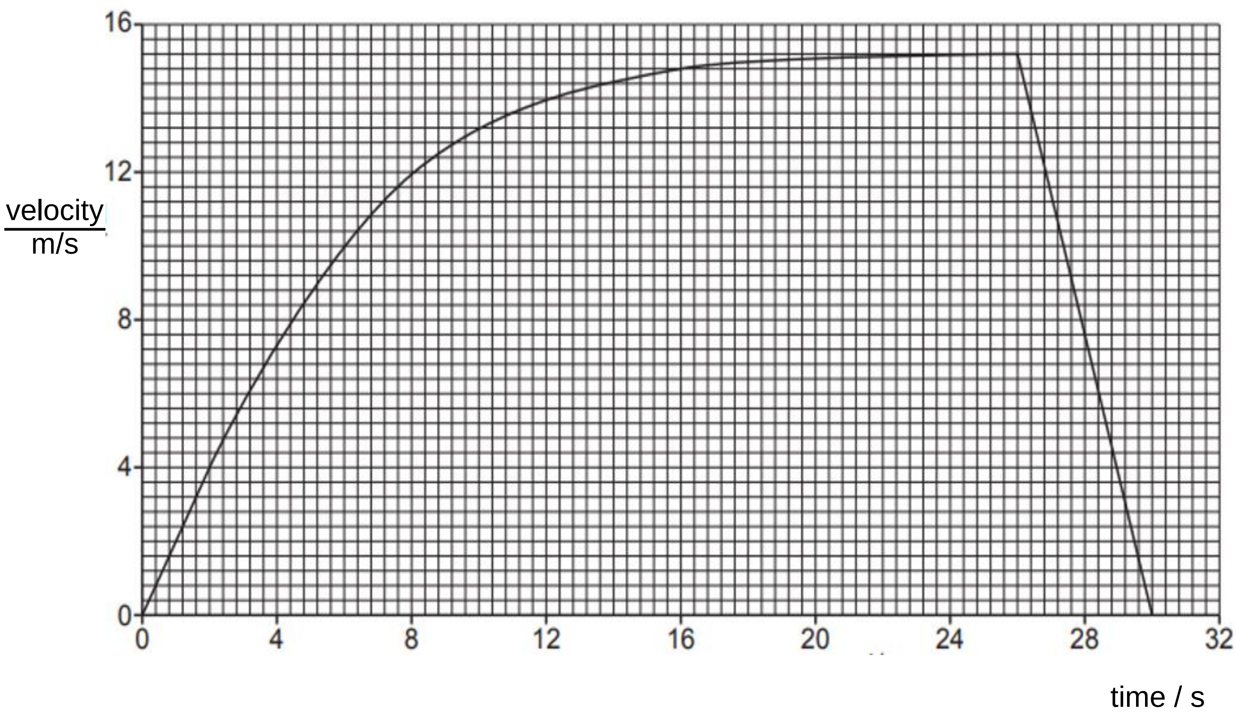

Fig.1.2

(a) Explain, using ideas about forces, why the speed varies in the way shown in Fig. 1.2 between t = 0 and t = 26 s.

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(b) Explain how the graph shows that the child and the sledge reach terminal velocity.

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

(c) At t = 26 s, the front of the sledge is 35 m from the wall.

Determine if the child is able to come to a stop before hitting the wall.

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

[2]

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

(d) State the main energy changes during time t = 24 s to t = 26 s.

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

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

(e) At t = 26 s, when the brakes are first applied, the child jerks forward on the sledge.

Explain why.

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

[1]

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

Total: [7]

2 Fig. 2.1 shows the velocity-time graph of an object that was thrown vertically upwards on an unknown planet X. The object falls back down due to planet X's gravity and rebounds once from the ground.

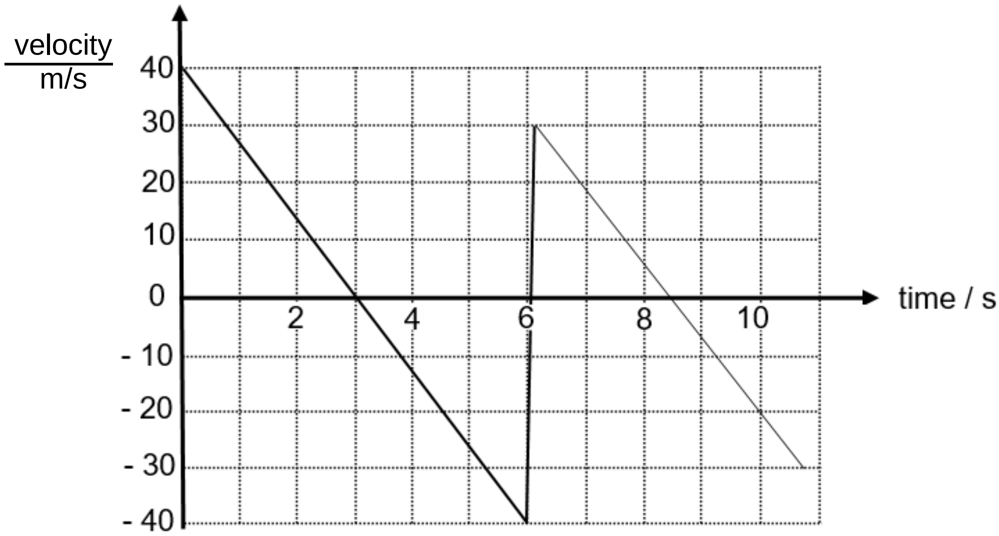

Fig. 2.1

(a) State the time which the ball rebounds from the ground.

time = ………………..……………….. [1]

(b) Explain how the graph indicates that energy is lost during the rebound.

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

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

(c) Determine the gravitational field strength of planet X.

gravitational field strength = …………………………… [2]

(d) Explain how the graph in Fig. 2.1. suggests that planet X does not have an atmosphere.

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

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

Total: [5]

3 Fig 3.1 shows a crane with a boom angle of 30 ° used on construction sites to lift heavy loads. The length of the crane boom is 45.0 m and the perpendicular distance of the load to the pivot X is 22.0 m. Table 3.1 shows the maximum load the crane can support at different boom angles.

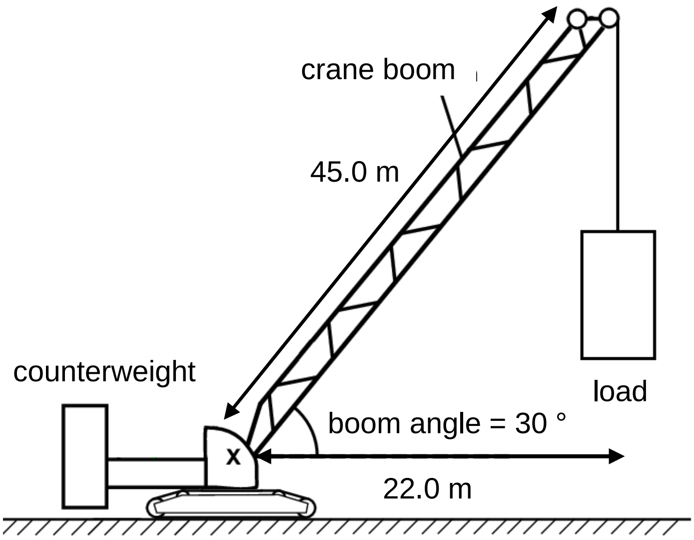

Fig. 3.1

Table 3.1

boom angle / °	maximum load / N
30	11 500
45	14 000
60	20 000

(a) Explain why the maximum load increases as the boom angle increases.

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

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

(b) **(i)** Calculate the maximum moment that the crane can support when the boom angle is 30 °.

maximum moment = …………………………… [1]

(ii) Given that the counterweight is 5.0 m away from the pivot X when the boom angle is 30 °, calculate the weight of the counterweight.

weight = ……………………… [1]

Total: [4]

4 Fig. 4.1 shows a 4.0 kg block being released from point P. The track is frictionless except for the rough surface between Q and R, which is 2.0 m long. The block slides down the track, hits a spring at S and compresses the spring 0.20 m from its equilibrium position before coming to rest momentarily.

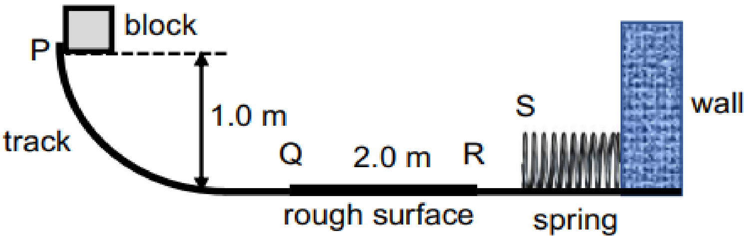

Fig. 4.1

(a) Calculate the speed of the block at Q.

speed = …………….……….. [2]

(b) After the block compressed the spring by 0.20 m from its equilibrium position, the energy stored in the spring is 4.5 J.

Calculate the average frictional force acting against the block along the rough surface.

average frictional force = ……………………….. [2]

Total: [4]

5 Fig. 5.1 shows a water gun that makes use of pressure exerted on a trigger to spray water out of a nozzle.

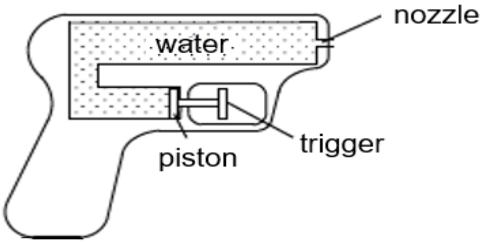

Fig. 5.1

(a) The cross-sectional areas of the piston and nozzle are 2.0 cm^2 and 0.08 cm^2 respectively. If a force of 5 N is exerted on the trigger, calculate the force exerted on the water leaving the nozzle.

force = …………………….……….. [2]

(b) When the force of 5 N is applied, the piston moved a distance of 0.6 cm.

(i) Determine the mass of water moved by the piston, given that the density of water is 1 g / cm^3.

mass = …………….….………… [1]

(ii) Calculate the work done on the water in the water gun.

work done = ……………...……….. [1]

(c) The volume of water leaving the water gun per second is equal to the volume leaving the nozzle per second.

Suggest why the speed of the water leaving the nozzle is greater than the speed of the water in the barrel.

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

Total: [7]

6 Fig. 6.1 shows how the resistance of a thermistor varies with temperature.

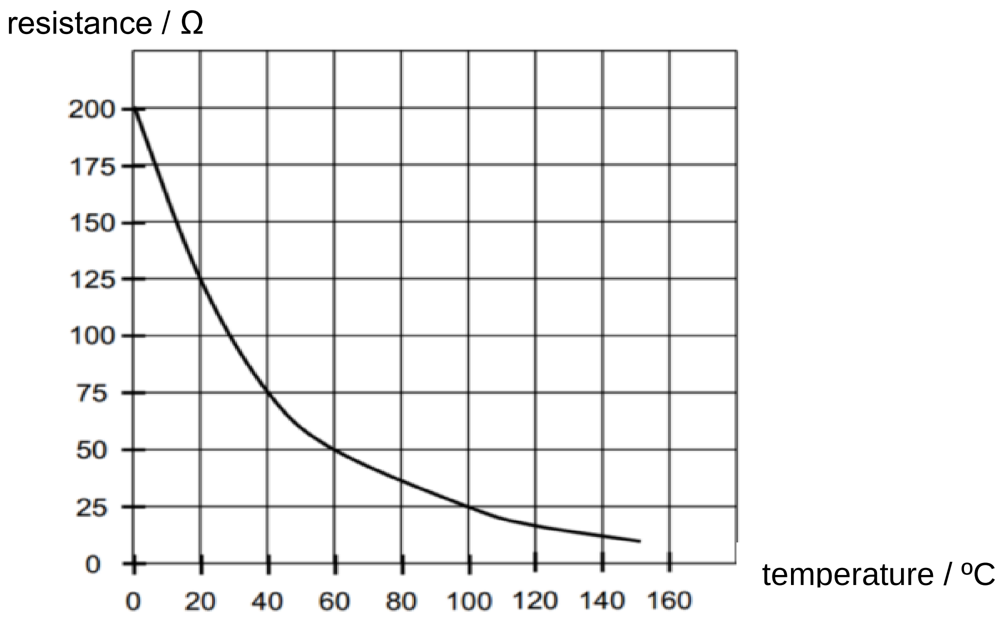

Fig. 6.1

The thermistor is connected in a circuit with a heating element as shown in Fig. 6.2.

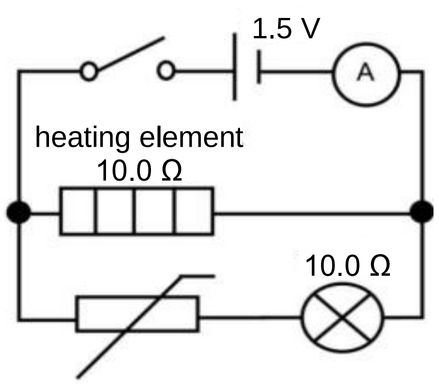

Fig. 6.2

(a) When the lamp first lights up, the current flowing through it is 17.6 mA.

(i) Calculate the potential difference (p.d.) across the thermistor when the lamp lights up.

p.d. = ………………………… [2]

(ii) Determine the temperature at which the lamp first lights up.

temperature = ………………………. [2]

(b) Thermistors are used in infra-red toasters and convection oven as shown in Fig. 6.3. An infra-red toaster emits infra-red radiation of different frequencies to cook the surface and the interior of the food concurrently. The convection oven uses a heater to warm up the air and a fan to circulate the hot air within the oven to cook food.

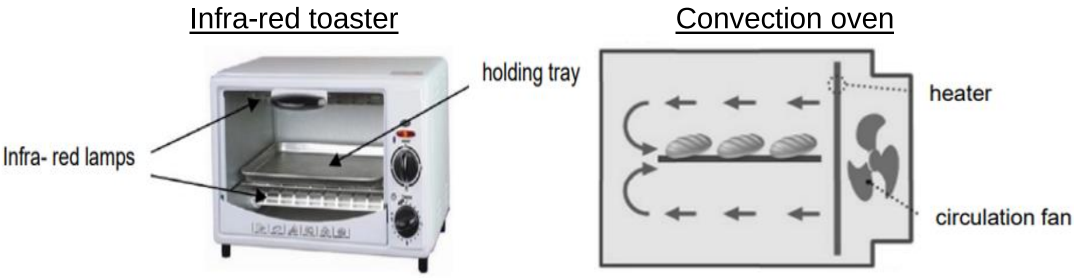

Fig. 6.3

Discuss why the infra-red toaster cooks the same type and amount of food faster than the convection oven.

……………………………………………………………………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………………..

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

Total: [6]

7 Fig. 7.1 shows two types of filament lamps A and B, one with its filament wire coiled and the other with its filament wire uncoiled. Table 7.1 summarises the design and characteristics of the two filament lamps A and B.

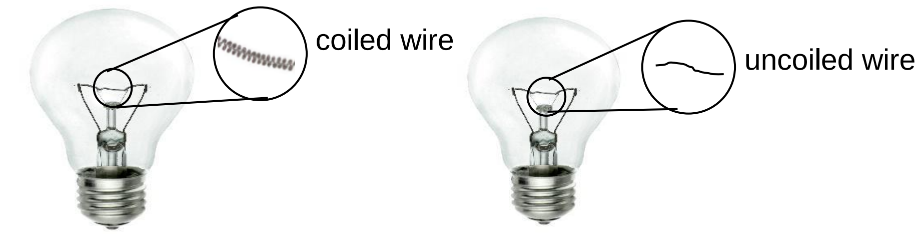

Fig. 7.1

Table 7.1

lamp	characteristics of filament wire		
	material	coiled / uncoiled	resistivity / Ω m
A	tungsten	coiled	5.38
B	copper	uncoiled	1.72

(a) Using Table 7.1, state and explain which lamp will give off the brightest light.

……………………………………………………………………………………………..

……………………………………………………………………………………………..

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

(b) The two non-ohmic filament lamps in Fig. 7.1 are supposed to be connected in parallel. However, an electrician makes a mistake and connects the two lamps in series instead.

Explain why the resistances of lamps A and B decrease when connected in series compared to when they are connected in parallel.

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

(c) The fuse is also wrongly connected into the earth wire of the circuit. Describe what happens to the fuse, lamp and user when the live wire touches the metal surface of the filament lamp.

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

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

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

Total: [7]

8 Carbon-14 is an isotope of carbon. It undergoes radioactive decay with a half-life of 6000 years. The age of a sample of wood is found using the carbon-14 that it contains.

(a) The count rate of the carbon-14 in the sample of wood is initially 1600 counts /minute. On Fig. 8.1 draw a graph to show how the count rate will vary over the next 24000 years. The initial count rate is already marked with an x.

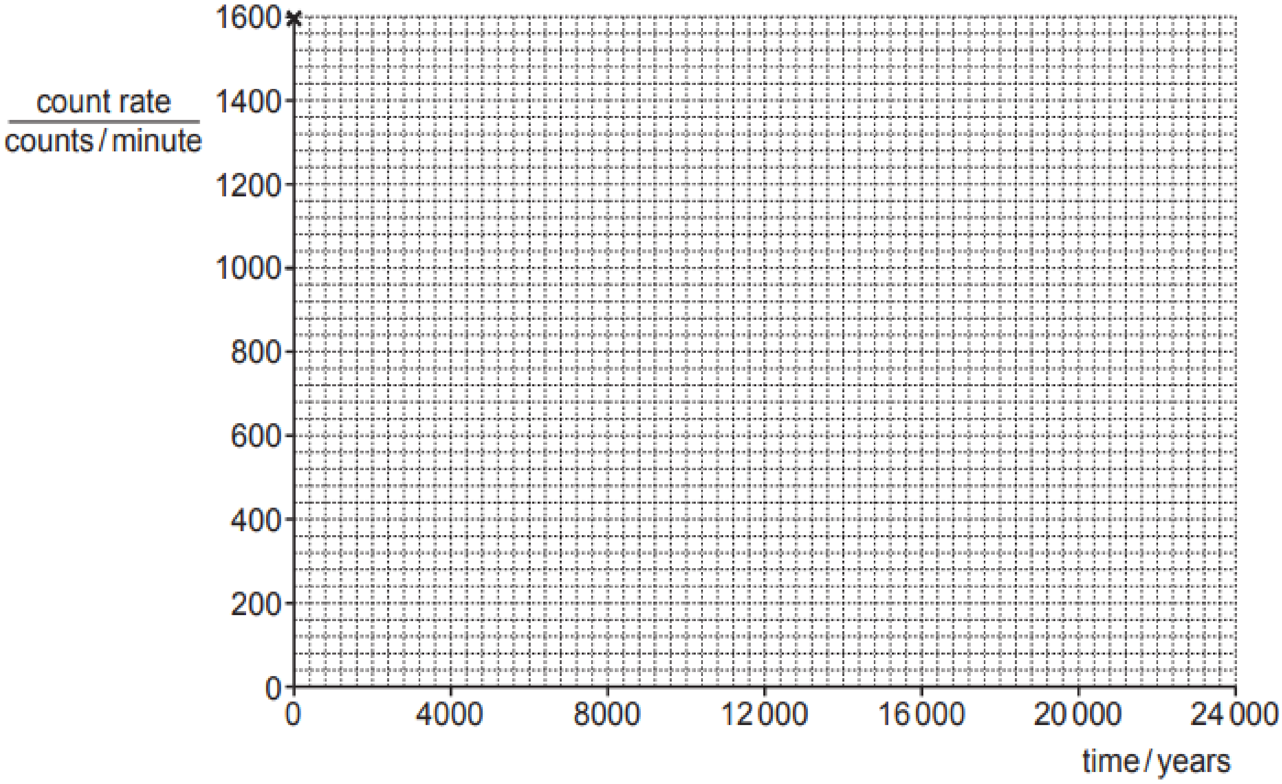

Fig. 8.1

[2]

(b) Given that the count rate of the sample of wood was 500 counts / minute, use Fig. 8.1 to determine the age of the sample of wood.

age = ……………………… [1]

(c) Another radioactive source is then moved and placed 10 cm from the G.M. tube as shown in Fig 8.2.

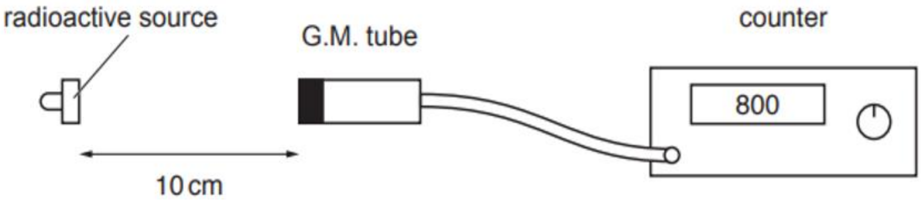

Fig. 8.2

A piece of metal 5 mm thick is placed between the source and the G.M. tube as shown in Fig. 8.3. The readings on the counter have been corrected for background radiation and show the count rate due to the source.

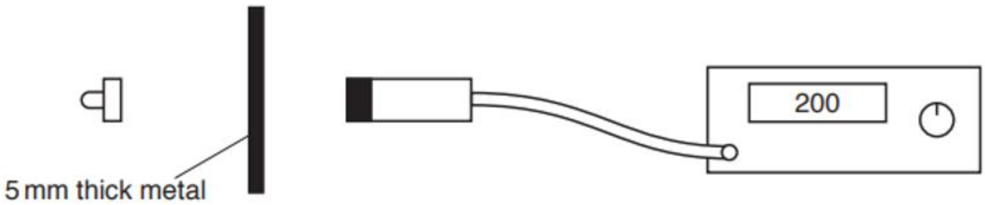

Fig. 8.3

Explain how the readings show that the source emits β-particles and Y-radiation.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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

Total: [5]

9 Fig. 9.1 shows a cross-section of a self-powered flashlight. This flashlight uses the Faraday's Law of Electromagnetic Induction to create the electricity it needs to charge itself. When the flashlight is shaken sideways, a magnet slides back and forth through a copper wire coil. This action produces electricity which is then stored in a super-capacitor.

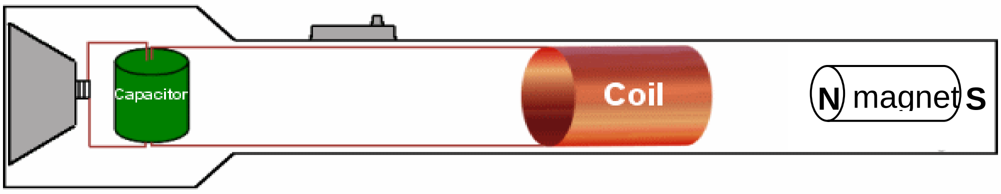

Fig. 9.1

(a) Explain, using your knowledge of Lenz's Law, how the action of shaking the flashlight sideways produces current that is alternating.

....

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.... [3]

(b) When the self-powered flashlight in Fig 9.1 is shaken, a sound is produced. Explain how the sound travels from the flashlight to the person's ear.

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....

....

.... [2]

Total: [5]

10 Fig. 10.1 shows a "wave maker" with a magnet held by a string, which is fixed to a wall in a water tank. The position of the magnet when the current is switched off is shown in Fig. 10.1.

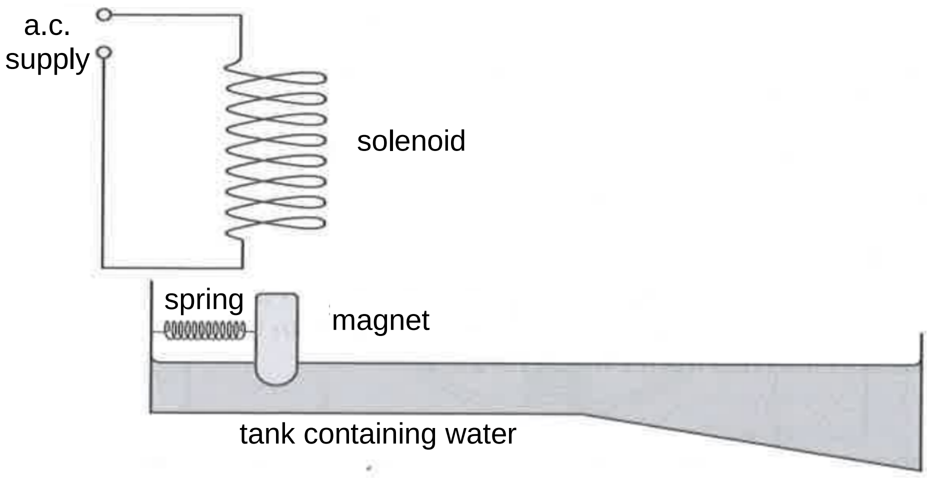

Fig. 10.1

(a) Explain how the magnet generates waves when the switch is closed.

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

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

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

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

(b) Suggest a modification that could be made to the set-up to generate waves of higher amplitude.

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

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

(c) Fig. 10.2 is a scaled diagram of the "wave maker", viewed from the top. Position B is at the edge of the "wave maker" before the tank depth changes.

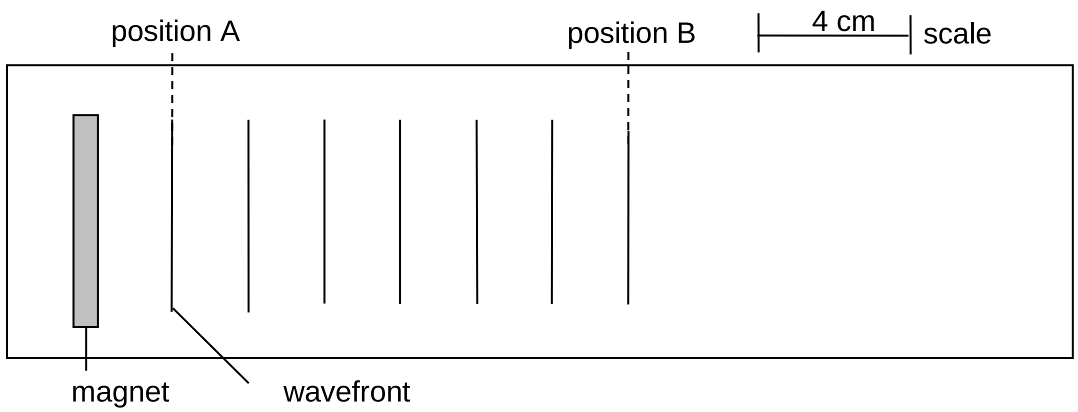

Fig. 10.2 *(drawn to scale)*

(i) State what is meant by the term *wavefront*.

…………………………………………………………………………………………………

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

(ii) The wavefront shown at position A in Fig. 10.2 takes 4.0 s to travel to position B. Determine the speed of the wave.

speed = …………………………… [1]

(iii) Calculate the frequency of the a.c. supply.

frequency = …………………………… [1]

(d) In terms of amplitude, frequency and wavelength compare and comment on the similarities and differences of the waves at the shallow and deep ends of the tank.

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

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

(e) Draw on Fig 10.2, the wavefront observed in the tank after position B. [1]

Total: [10]

11 A student wishes to determine the efficiency of an electric kettle that she has just bought. Details about the experiment she conducted are shown in Fig. 11.1.

Mass of water poured into the kettle: 0.75 kg

Starting temperature of water: 25.5 °C

Time taken for the electric kettle to automatically switch 'OFF' after being switched 'ON' is 2 min 38 seconds.

Mass of water remaining in the kettle after boiling: 0.74 kg

A sticker at the bottom of the electric kettle shows the following

Model SG-620

240V ~ 50 Hz 2000W

DO NOT IMMERSE IN ANY LIQUID

She also found the following information while doing research for her experiment:

- Specific heat capacity of water = 4200 J/kg°C
- Specific latent heat of fusion = 334 kJ/kg
- Specific latent heat of vaporization = 2260 kJ/Kg

Fig. 11.1

(a) **(i)** Calculate the total energy transferred to the kettle while it was switched 'ON'.

total energy = ... [1]

(ii) Determine the efficiency of the kettle based on the information in Fig. 11.1.

efficiency = ... [2]

(b) The student knows that her calculated efficiency is not accurate as thermal energy is lost by the water and the kettle during heating.

She decides to conduct a second experiment by placing 800 g of shaved ice at 0 °C into the kettle. She then switched ‘ON’ the kettle for the same amount of time as her earlier experiment. At the end of the experiment, she measured that 11.2 g of shaved ice remained in the kettle.

(i) Explain why the temperature remains constant at 0 °C when the shaved ice melts.

....

....

....

.... [2]

(ii) Determine the efficiency of the kettle based on her second experiment.

efficiency = ... [2]

(iii) Explain why the efficiency of the kettle is higher for her second experiment.

....

.... [1]

(c) Using the kinetic model of matter, explain why the pressure of the water vapor inside an electric kettle increases during heating.

....

....

....

....

.... [2]

Total: [10]

Section B [10 marks]

Answer **one** question from this section.

12 Many modern luxury cars today have a rain sensor that will automatically turn on the wipers on the glass windshield when rain is detected. The rain sensor consists of an infrared light source (LED) on one side of the windshield and a light dependent resistor (LDR) on the other. Infrared light is beamed at a 45-degree angle into the windshield, and the path of light when there is no rain is as shown in Fig. 12.1.

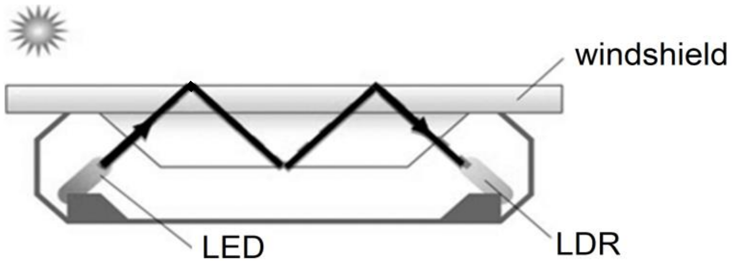

Fig. 12.1

(a) Explain why the infrared light travels in such a path as shown in Fig. 12.1.

....

....

....

.... [2]

When there is rain on the windshield, some of the infrared light is able to be refracted out of the windshield, as shown in Fig. 12.2.

This is because rain water has a higher refractive index (n = 1.33) as compared to air (n = 1.00). Hence less light is detected by the LDR and this causes the windshield wipers to be turned on.

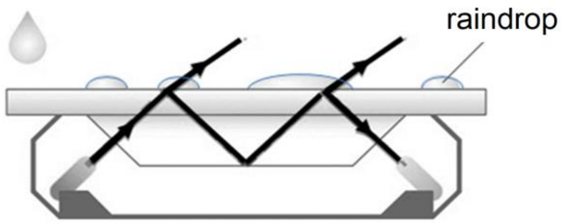

Fig. 12.2

For the infrared light to be refracted out of the windshield, the maximum angle that the light can leave the air/raindrop surface is 90°, as shown in Fig. 12.3.

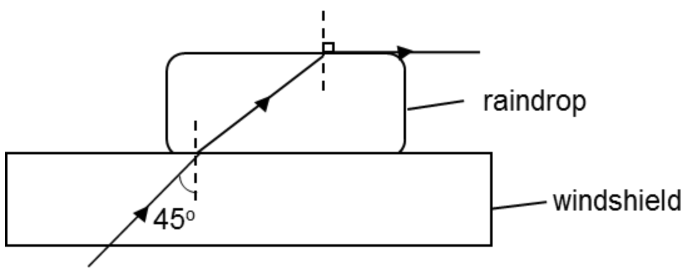

Fig. 12.3

(b) Given that:

$$n_{water} = \sin i_{air} / \sin r_{water}$$
$$n_{glass} = \sin i_{air} / \sin r_{glass}$$

Show that for light to be refracted out of the windshield through the raindrops, the refractive index of the glass should be less than 1.88. [3]

(c) The LDR is connected as part of a potential divider circuit in order to operate the windshield wipers. Fig. 12.4 shows part of the circuit, with two missing components: a LDR and a variable resistor.

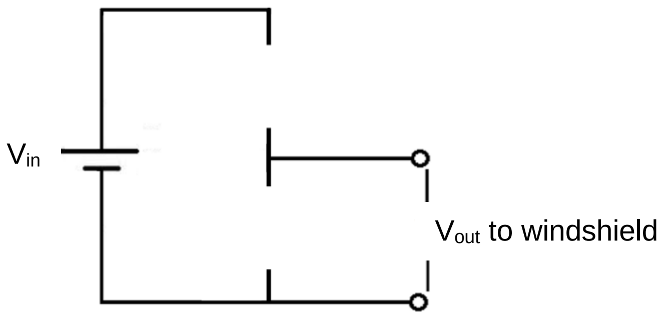

Fig. 12.4

(i) Complete the circuit by drawing the LDR and variable resistor in Fig. 12.4. [2]

(ii) Explain how the LDR and variable resistor drawn in Fig. 12.4 allow the wiper to be turned on during rainy days.

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

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

(d) State one advantage in using a variable resistor for the rain sensor instead of a fixed resistor in the circuit.

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

Total: [10]

13 A simple a.c. generator is used as the mains supply to power up a house. Fig. 13.1 shows how the e.m.f. produced by the generator varies with time.

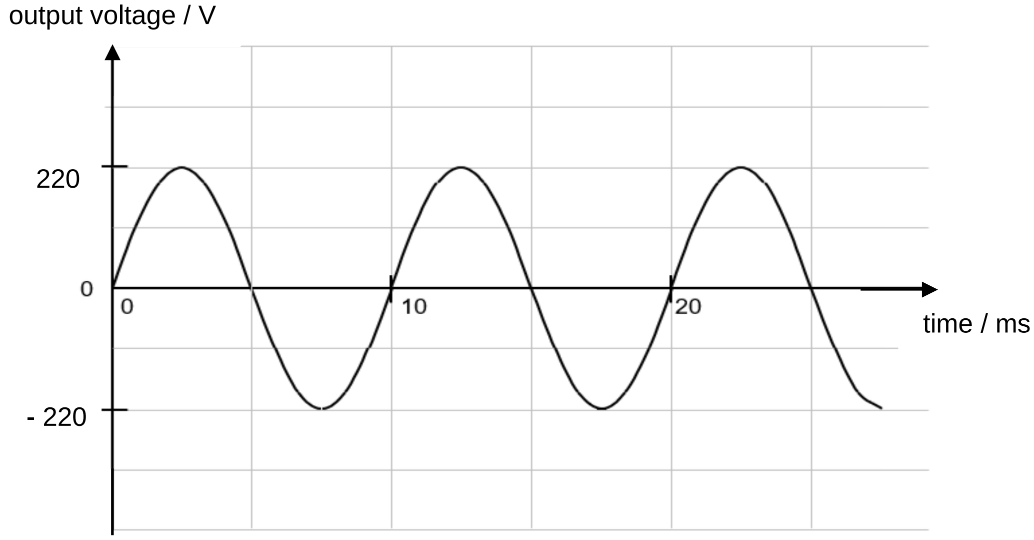

Fig. 13.1

(a) With reference to Fig. 13.1,

(i) determine the rotating speed of the coil of the generator, in terms of revolution per second,

rotating speed = …………………… revolution per second [1]

(ii) state the time at which the coil of the generator is first parallel to the magnetic field,

time = ………………………………… [1]

(iii) draw on Fig 13.1 what you would expect to see if the speed of rotation of coil is halved. [1]

(b) Fig. 13.2 shows the mains electric supply connected to the house. The house is far away from the mains electricity supply.

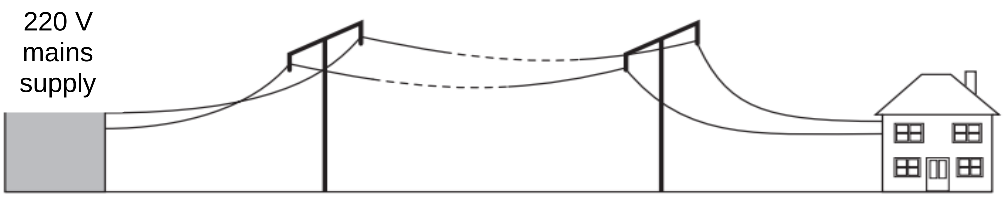

Fig. 13.2

The farmer uses 220 V lamps in the house, but they do not light up at full brightness. Suggest why the lamps are dim.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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

(c) To enable the lamps in the house to light up at full brightness, the farmer adds a step-up transformer A and a step-down transformer B, as shown in Fig. 13.3.

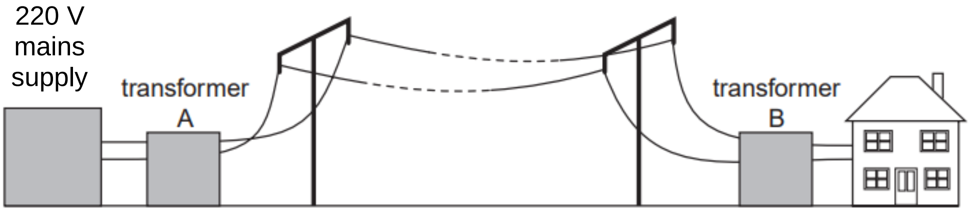

Fig. 13.3

Transformer B steps down the voltage from 3.3 kV to 220 V for the house. The farmer has the choice of using four types of coils with different number of turns as shown in Table 12.4.

Table 13.4

coil	number of turns
J	50
K	100
L	1 000
M	1 500

(i) Based on Table 13.4, select the most suitable pair of coils for making the primary coil and secondary coil of the transformer B. Explain your choice.

....

....

....

.... [2]

(ii) Assume that the transformer is 75 % efficient and the power output is 15 kW, calculate the current flowing in the primary coil.

current = ... [2]

(iii) Describe one feature that can improve the efficiency of this transformer.

....

....

.... [1]

Total: [10]

End Of Paper

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