HUA YI SECONDARY SCHOOL
PRELIMINARY EXAM 2024

4-G3

NAME

CLASS

INDEX NUMBER

PHYSICS **6091/01**

PAPER 1

22 August 2024

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue, or correction fluid.
Write your Name, Class, and Index Number on the Answer Sheet in the spaces provided.

There are **forty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A, B, C** and **D**.
Choose the one you consider correct and record your choice **in soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

Paper 1	40

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Setter: Mr Tan PE

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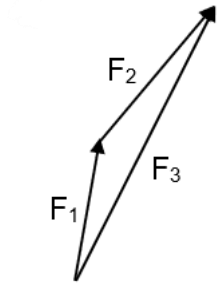
1 A strand of hair is 10^{-4} m thick.

How many times larger is this thickness as compared with the average diameter of an atom?

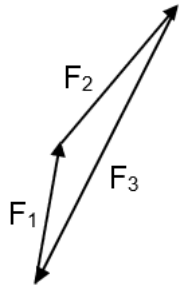
A 10^3 **B** 10^4
C 10^5 **D** 10^6

2 Which of the following shows zero resultant force when forces F_1, F_2 and F_3 are added?

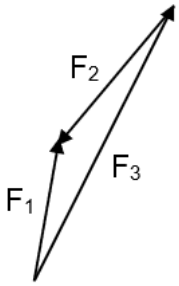
A



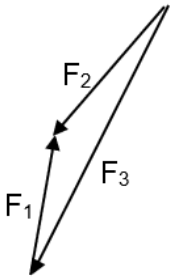
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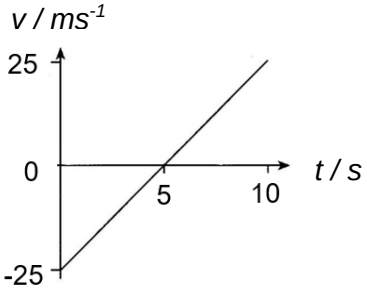
C



D



3 The motion of an object in a straight line over 10 s is shown by the velocity-time graph.



Which statement about the motion of the object is **not** correct?

A The object has positive acceleration.
B The object has zero average velocity.
C The object is constantly in motion.
D The object returns to its start point.

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4 Which statement describes speed and velocity correctly?

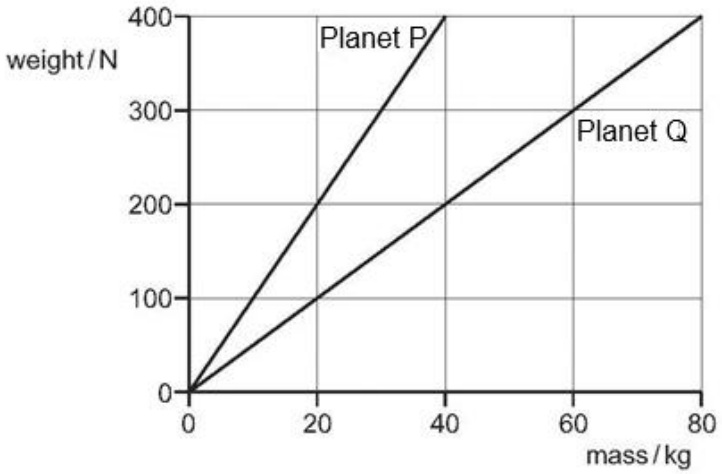
A Speed and velocity are vector and scalar quantities respectively.
B Speed and velocity are base and derived quantites respectively.
C Speed may not change when velocity changes.
D Speed always changes when velocity changes.

5 A force is applied to an object of mass 3 kg and it accelerates at 0.5 m/s^2 from rest on a smooth surface. When the same force is applied on the same object on a rough surface, the acceleration is reduced to 0.2 m/s^2.

What is the deceleration if the force is removed from the object when it is moving on the rough surface?

A 0.17 m/s^2 **B** 0.27 m/s^2
C 0.30 m/s^2 **D** 0.50 m/s^2

6 The diagram shows how weight varies with mass on planets P and Q.



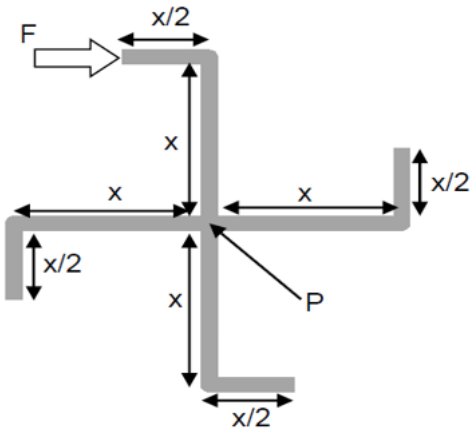
An object weighs 400 N on planet P. The object is then taken to planet Q.

Which of the following is correct?

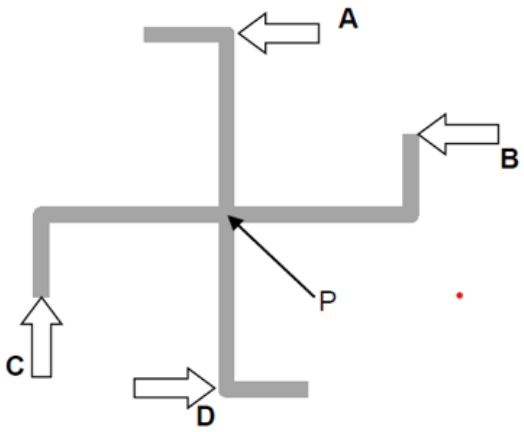
A The density of the object is higher on planet Q.
B The gravitational field strength on planet P is lower than that on planet Q.
C The mass of the object on planet Q is 80 kg.
D The weight of the object on planet Q is 200 N.

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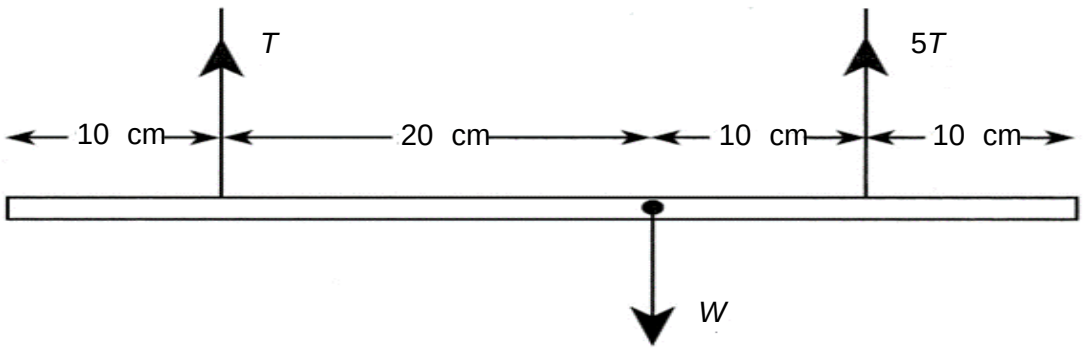
7 An object was spinning about its pivot point, P, due to a force F as shown.



Which direction should a force, 2F, be applied to stop the spinning?



8 A non-uniform rod of unknown weight *W* is suspended by two strings as shown in the diagram. The tension in one of the strings is 5 N.

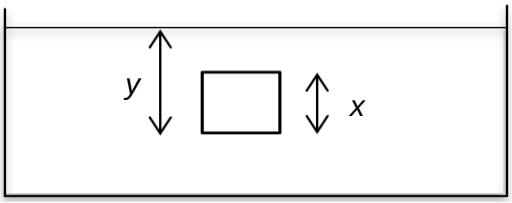


What is the tension *T* in the other string?

A 2.5 N
B 5.0 N
C 7.5 N
D 12.5 N

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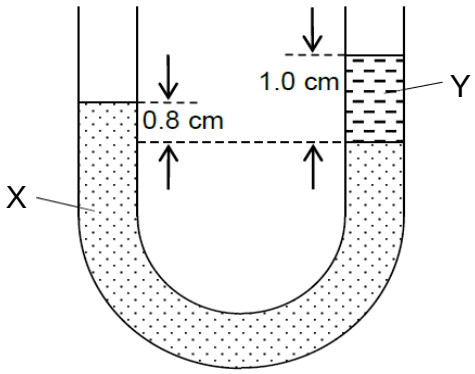
9 The diagram shows a solid cube of side x m located at y m below water surface of an open tank that is filled with water. The density of water is ρ and the atmospheric pressure is P. g is Earth's gravitational field strength.



What is the pressure experienced at the bottom of the box?

A $P + \rho gy$
B $P + \rho g(y - x)$
C ρgx
D $\rho g(y - x)$

10 A U-shaped tube is filled with liquids X and Y.



What is the density of liquid X, ρ_x as compared to liquid Y, ρ_y?

A 0.2 ρ_y
B 0.8 ρ_y
C 1.25 ρ_y
D 1.8 ρ_y

11 Which of the following illustrates energy transfer mechanically by a force acting over a distance?

A A bungy jumper stretching a bungy as he jumps from the top of a tower.
B A person hearing music in a concert.
C A person resting and feeling the warm of the surroundings.
D An ice hockey player sliding on ice at constant velocity.

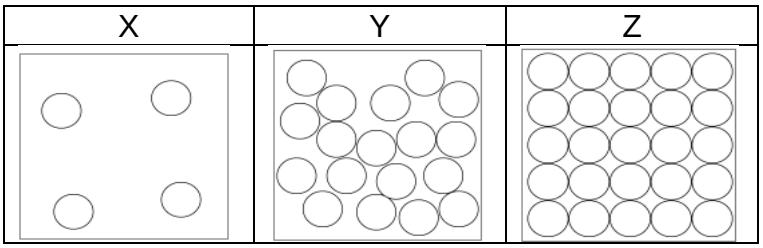
12 Illuminated smoke particles, suspended in air, are seen to move randomly.

Which of the following best describes cause of the movement of the smoke particles?

A The smoke particles are bombarded continuously by the air molecules.
B The smoke particles move due to bombardment by other smoke particles.
C The smoke particles move due to convection currents.
D The smoke particles move due to the energy gained from the illuminated light.

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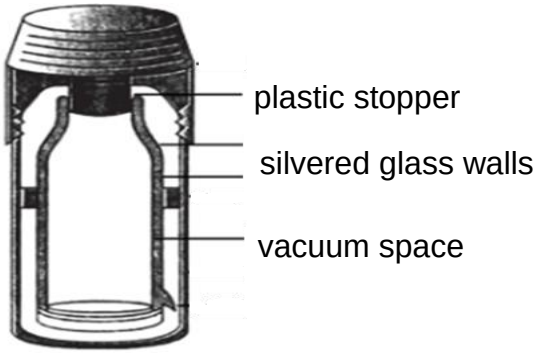
13 Diagrams X, Y and Z show three different states of a pure substance.



Which statement correctly describes X, Y and/or Z?

A X has the lowest temperature.
B Y has lower average kinetic energy than Z.
C Y is formed when heat is supplied to X.
D Z is formed when heat is removed from Y.

14 The diagram shows the sectional view of a thermal flask.



Which statement correctly describes how thermal energy transferred is reduced through a thermal flask?

	parts	conduction	convection	radiation
A	plastic stopper	yes	yes	no
B	silvered glass walls	no	no	yes
C	silvered glass walls	yes	no	yes
D	vacuum space	yes	yes	yes

15 Which statement is true about the internal energy changes during boiling and evaporation?

	boiling	evaporation
A	no change	no change
B	no change	decrease
C	increase	no change
D	increase	decrease

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16 A 200 g of solid at 100°C is placed into a container that contains 200 g of liquid at 20°C. The specific heat capacity of the liquid is 4 times larger than the specific heat capacity of the solid.

Assuming that the container has negligible specific heat capacity and no heat is lost to the surrounding, what is the final temperature of the solid?

A 36 °C
B 40 °C
C 80 °C
D 84 °C

17 In which of the situations is having a low specific heat capacity an advantage?

A fiber handle of a frying pan
B glass wall of an oral thermometer
C metal bottom of a frying pan
D water in a hot water storage tank

18 A musical instrument produces two notes. The first note has a wavelength of 10 m, a period of 30 s and an amplitude of 5 cm. The second note has a higher pitch and is softer.

Which is the wavelength and amplitude of the second note?

	wavelength / m	amplitude / cm
A	5	3
B	5	10
C	20	3
D	20	10

19 A ship that is stationary on the surface of the sea sends pulses of sound vertically downwards towards the seabed. Each pulse that reflects from the seabed is received 1.0 s after it is sent out. A whale swims under the boat and a pulse is received 0.60 s after it is sent out. The speed of sound in sea water is 1500 m/s.

What is the distance of the whale above the seabed?

A 300 m
B 450 m
C 600 m
D 750 m

20 A wall made of a particular material is used to shield electromagnetic waves that have wavelengths longer than the wavelength of ultraviolet rays.

Which electromagnetic wave will be able to pass through the material?

A microwave
B radio wave
C visible light
D X-ray

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21 Which row gives an example of a longitudinal wave and of a transverse wave?

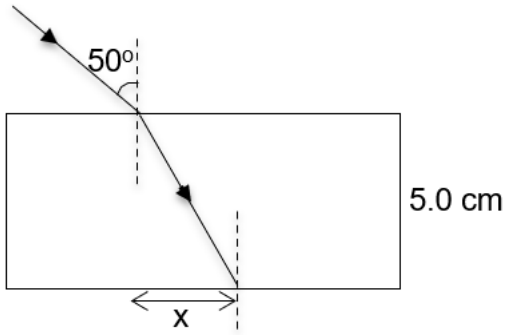
	longitudinal wave	transverse wave
A	light	ultrasound
B	microwaves	radio waves
C	radio waves	microwaves
D	ultrasound	light

22 Y and Z are electromagnetic waves. Both waves travel at the same speed in vacuum Y has shorter period than Z.

What could Y and Z be?

	Y	Z
A	radio wave	microwave
B	ultraviolet ray	infrared ray
C	visible light	X-ray
D	microwave	visible light

23 The diagram shows the refraction of a ray as it passes through a glass block of refract index 1.53. The width of the block is 5.0 cm.



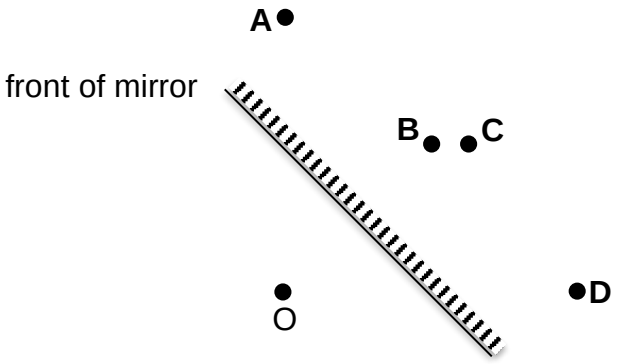
What is the angle of refraction of the incident ray, and the perpendicular displacement *x*?

	angle refraction / °	perpendicular displacement, x / cm
A	20	1.7
B	20	1.8
C	30	2.5
D	30	2.9

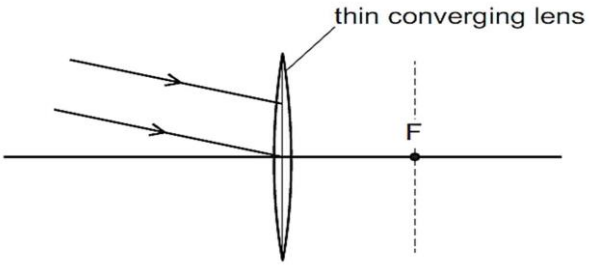
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24 The figure shows an object O that is placed in front of a plane mirror.

At which point **A**, **B**, **C** or **D** is the position of the image of O located?

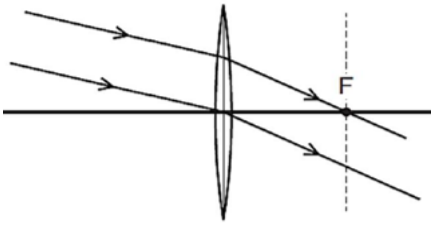


25 A parallel beam of light is incident on a thin converging lens. F is one focal point of the lens.

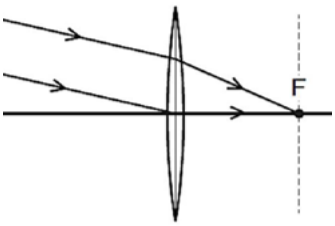


Which ray diagram shows the light after it has passed through the lens?

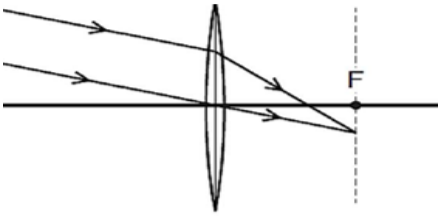
A



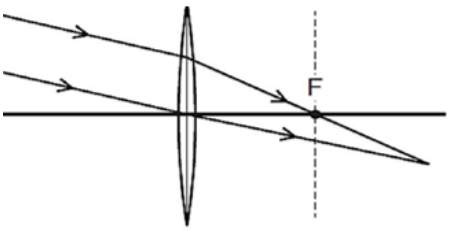
B



C



D



26 When a boy took off his layers of coats during winter, he observed sparks forming in between his clothes.

What is a possible explanation for this?

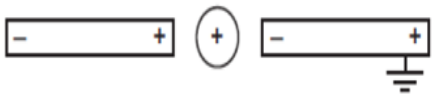
A The charges are transferred from the boy to the coat as he took them off.
B The humidity is lower in winter.
C There are more charges in the air during winter.
D There is a greater temperature difference between the boy and the surrounding.

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27 A positively-charged metal sphere is placed midway between two previously uncharged metal rods, one of which is connected to earth.

Which diagram shows the charges on the rods?

A



B



C



D



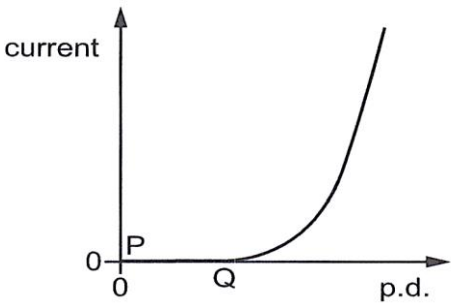
28 Lightning is an electrical discharge caused by imbalances between storm clouds and the ground, or within the clouds themselves. In one lightning occurrence between two storm clouds, the following data are collected:

potential difference / MV	current / kA	duration of occurrence / μs	electrical resistance / Ω	charge released / C
1.32	12	30	P	Q

What are the values of P and of Q?

	P	Q
A	0.11	0.36
B	0.11	360
C	110	0.36
D	110	360

29 The diagram shows how the current in a semiconductor diode varies as the potential difference (p.d.) across it increases from zero.

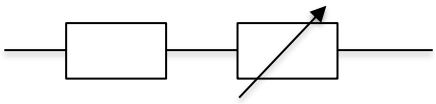


What is the resistance of the diode between P and Q, and how does it change as the p.d. increases from Q?

	resistance between P and Q	resistance after Q
A	very large	decreases
B	very large	increases
C	zero	decreases
D	zero	increases

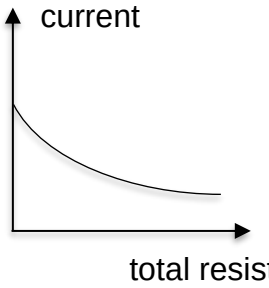
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30 The diagram shows part of a d.c. circuit where a fixed resistor is connected to a variable resistor that has a range of resistance from zero to a maximum value.

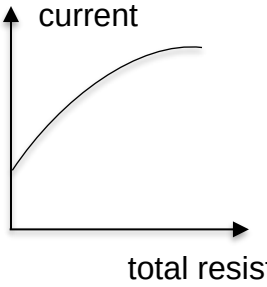


Which graph shows how the main current in the circuit varies with total resistance when the variable resistance is adjusted from zero to a maximum value?

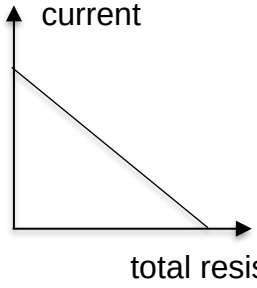
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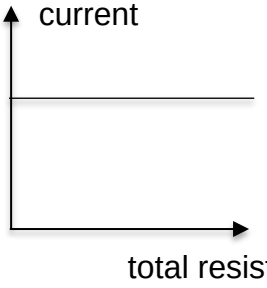
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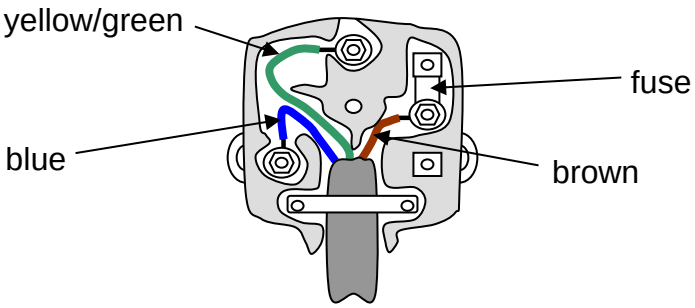
C



D



31 The diagram shows a 3-pin plug in a household.



The brown wire carries a current of 4.0 A when the appliance is switched on.

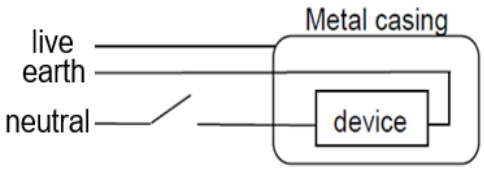
What would be the current flowing in the yellow/green and blue wires and the potential difference across the brown and blue wires?

	current flowing in		potential difference across brown and blue wires / V
	yellow and green wire / A	blue wire / A	
A	0.0	0.0	0
B	0.0	4.0	240
C	4.0	0	0
D	4.0	4.0	240

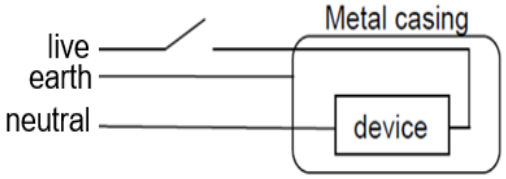
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32 Which one of the following electrical appliances is correctly wired?

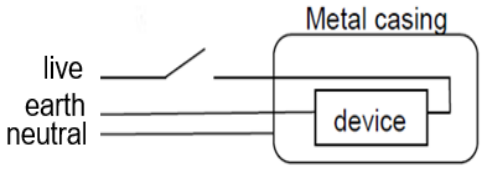
A



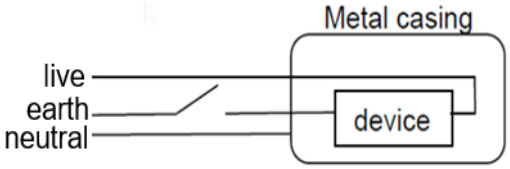
B



C



D

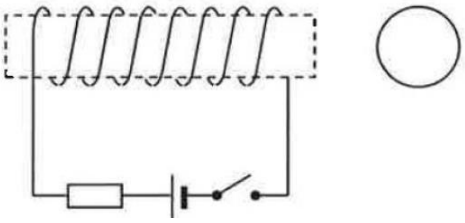


33 A household uses an electric heater with a power rating of 2 000 W for 5 hours a day in a month with 30 days.

If the monthly electricity cost is $45, what is the cost per kWh of electricity?

A $0.15
B $0.20
C $0.25
D $0.30

34 The solenoid is connected to a d.c. power supply. A magnetic compass is placed at the right side of the solenoid. The switch is turned on.

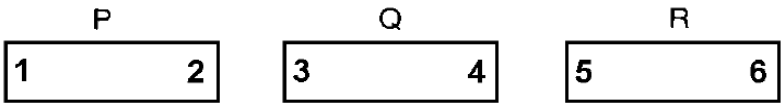


Which of the following statements is incorrect?

A Magnetic field is present around the solenoid and the connecting wires.
B The needle of the compass will point to the left.
C When a bar magnet is placed inside the solenoid, it will be demagnetised.
D When an iron bar is placed inside the solenoid, it becomes an electromagnet.

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35 Three metal bars P, Q and R are identical in size and shape. They are suspected of being magnets. Tests are carried out and it is found that there is attraction between poles 1 and 6, between 2 and 4, and between 2 and 6. However, there is repulsion between poles 2 and 3.



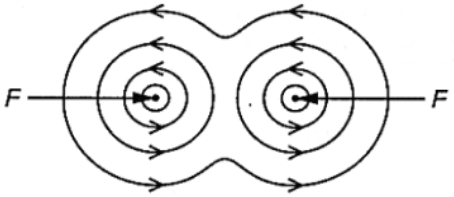
Which of these statements is correct?

A P and Q are magnets.
B P and R are magnets.
C Poles 2 and 5 would repel one another.
D All three metal bars are magnets.

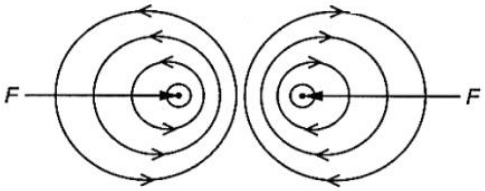
36 Two parallel, vertical wires each carries an out of page electric current.

Which diagram shows the magnetic field pattern around the wires and the direction of the force F on each wire?

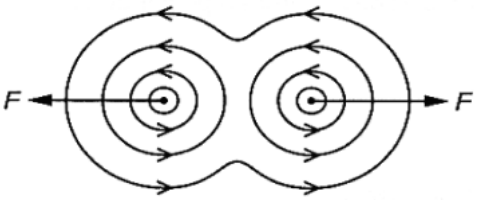
A



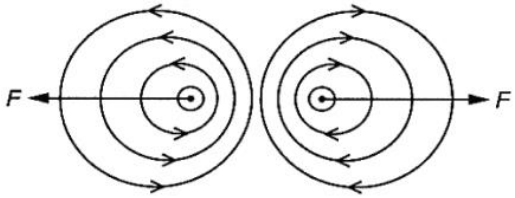
B



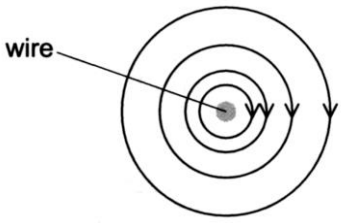
C



D

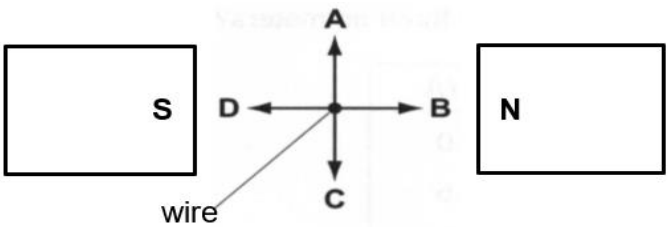


37 The diagram shows the magnetic field around a wire, when viewed from above.



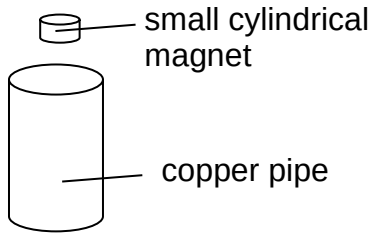
The poles of the magnet are placed on either side of the wire.

What is the direction of the force on the wire caused by the magnet?



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38 When a small cylindrical magnet is released from rest near the top of a copper pipe, the magnet falls very slowly through the pipe.



Which of the following will help to slow down the motion of the magnet further?

A use a glass pipe instead
B use a pipe made from a material of lesser friction
C use a pipe made from a material of higher resistivity
D use a stronger magnet of the same mass

39 Which statement describes this isotope of uranium $^{238}_{92}U$ correctly?

	neutron	proton	electron
A	92	146	0
B	119	146	146
C	146	92	0
D	148	92	92

40 Which statement describes nuclear fusion?

A The nucleus of an atom splits into two parts.
B The nucleus with high energy knocking off electrons from atoms to form ions.
C The unstable nucleus loses energy by emission of particles or radiation.
D Two light atomic nuclei combine to form one heavier nucleus.

End Of Paper

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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.

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Setter: Mrs Lim Kai Xin

[Turn Over

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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.

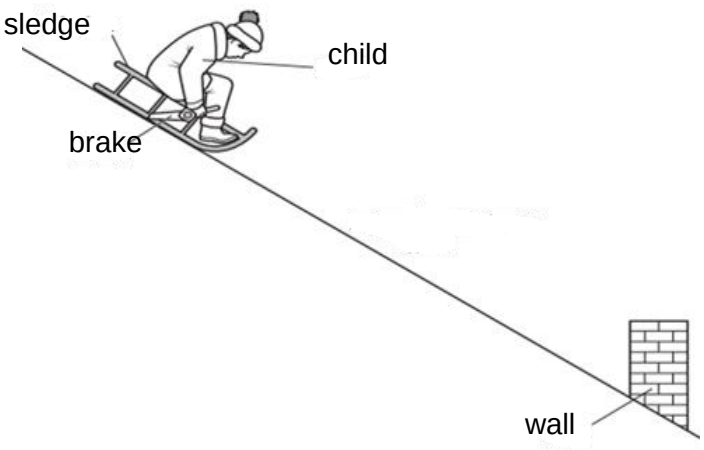


Fig.1.1

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.

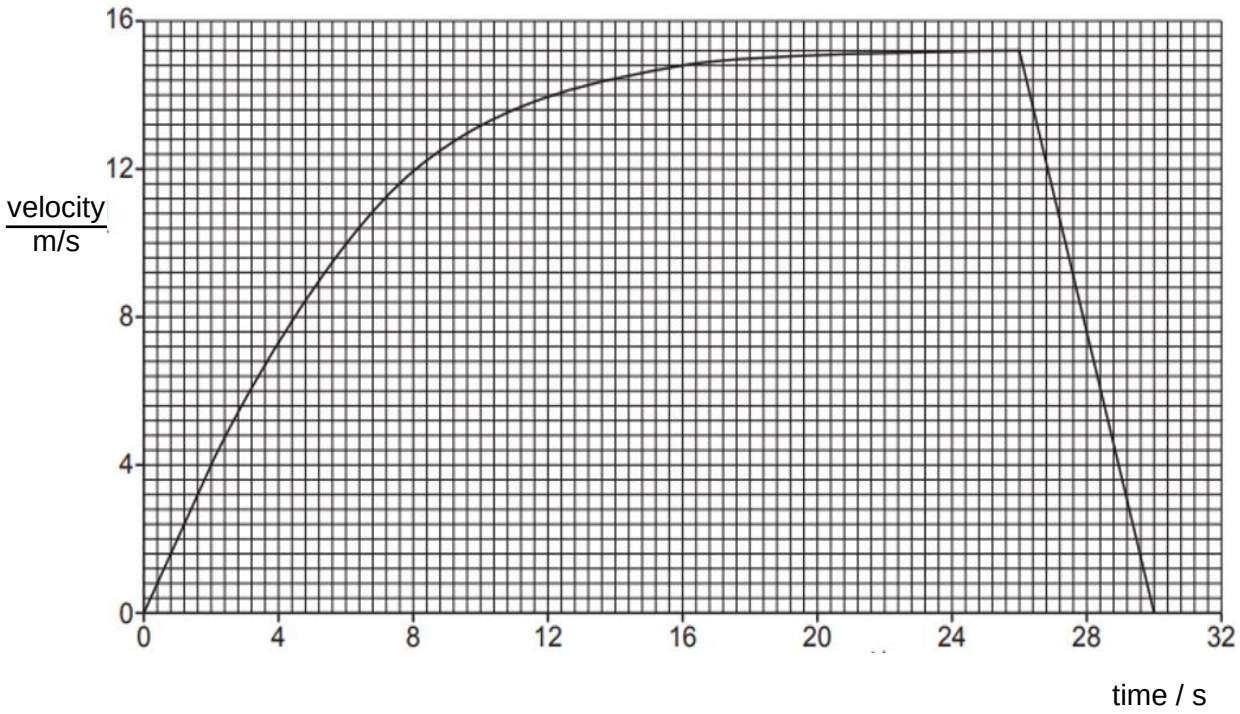


Fig.1.2

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(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.

……

……

……

……

…… [2]

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

……

…… [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]

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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.

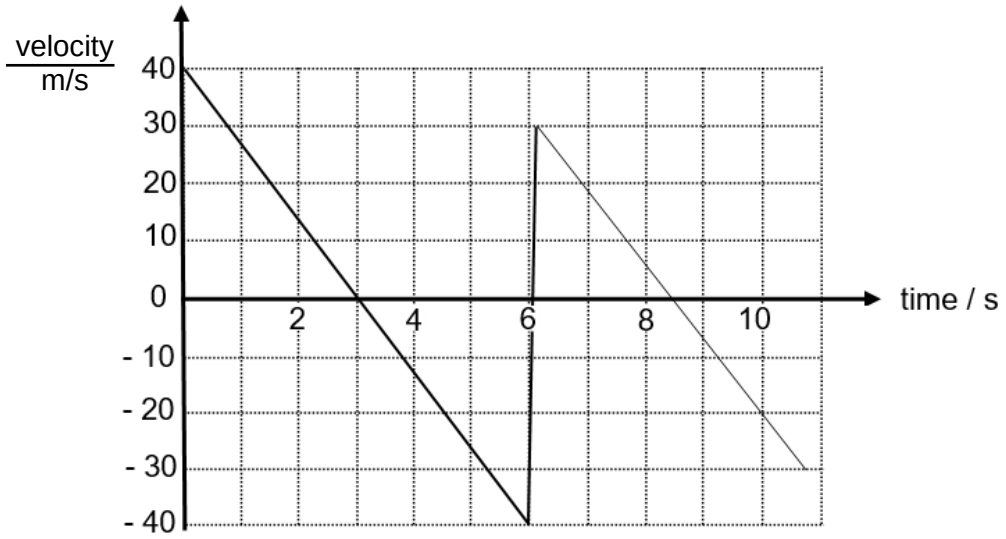


Fig. 2.1

(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]

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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.

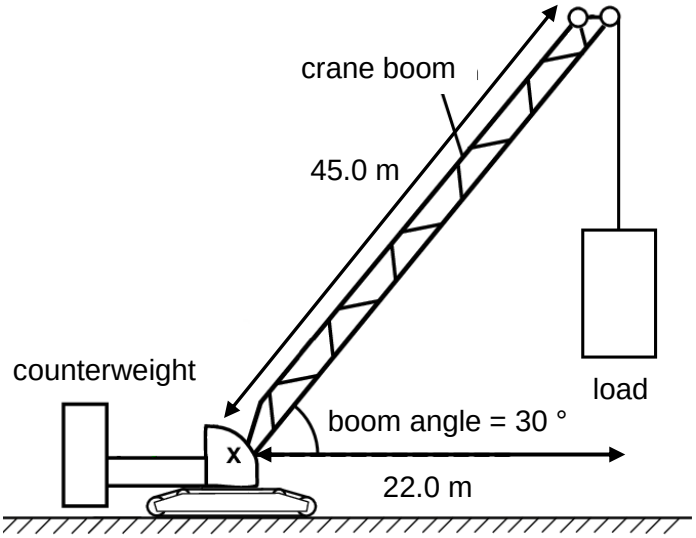


Fig. 3.1

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.

……..

……..

……..

…….. [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]

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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.

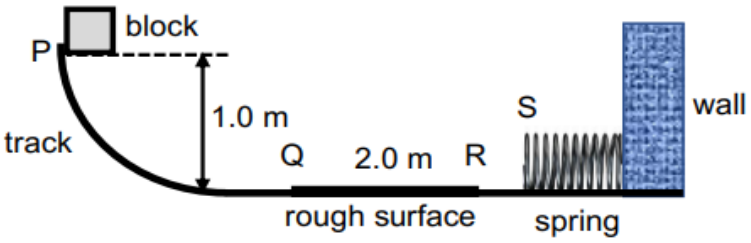


Fig. 4.1

(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]

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

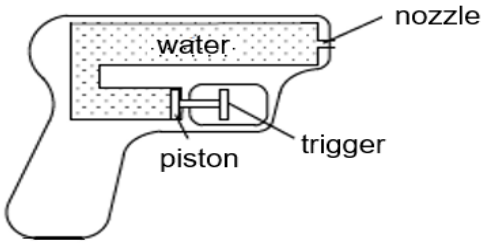


Fig. 5.1

(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.

……..

……..

……..

……..

…….. [3]

Total: [7]

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

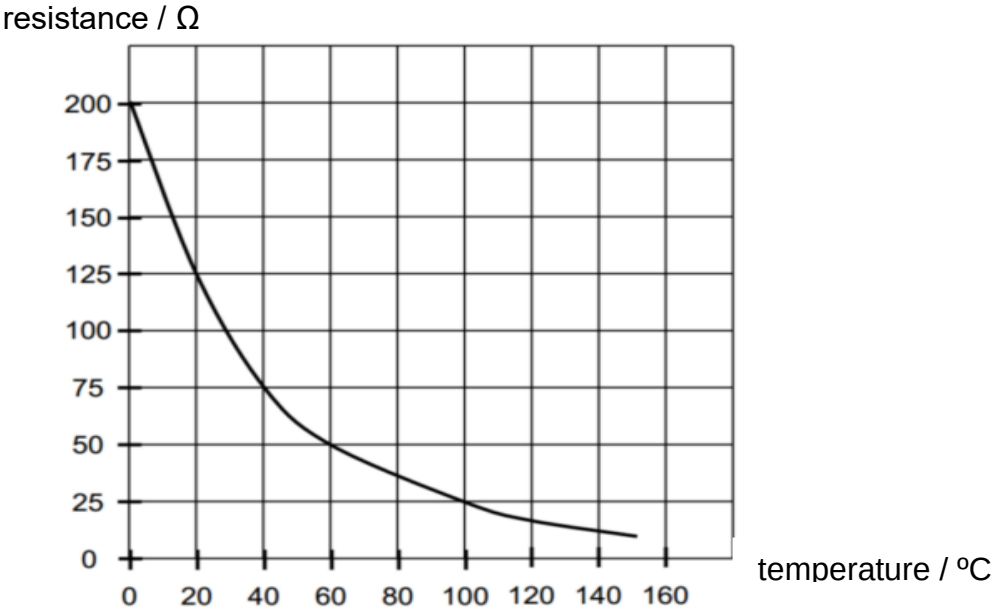


Fig. 6.1

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

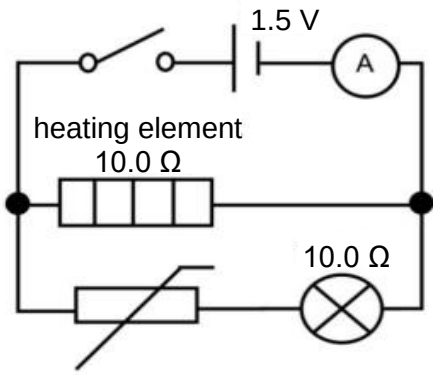


Fig. 6.2

(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]

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(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.

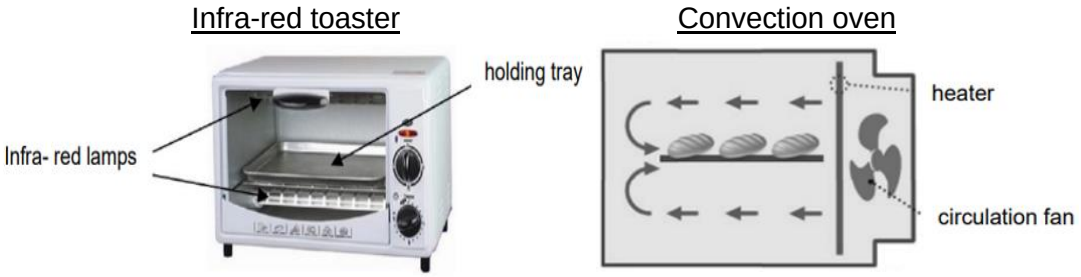


Fig. 6.3

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.

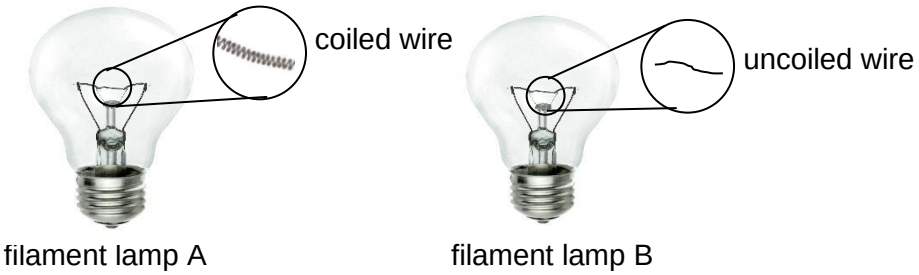


Fig. 7.1

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]

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(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.

……..

……..

……..

……..

……..

……..

…….. [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]

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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.

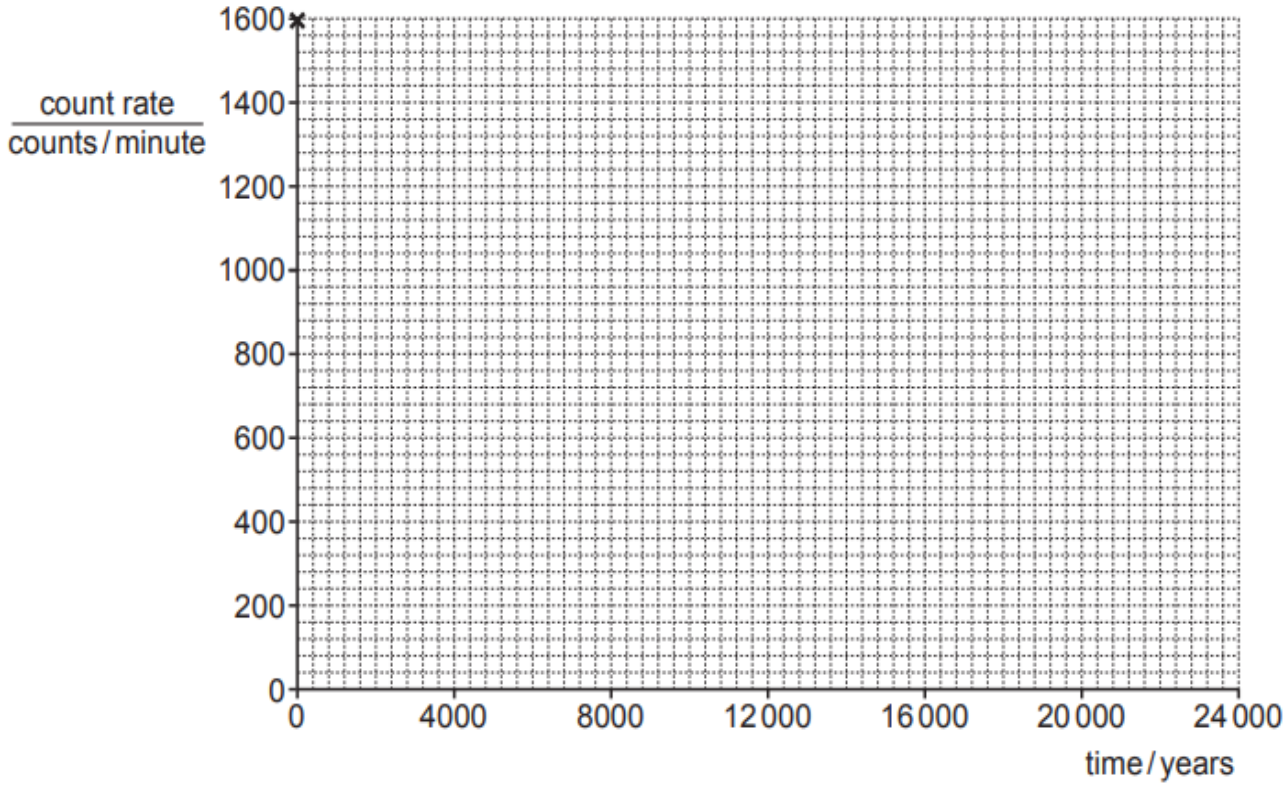


Fig. 8.1

[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]

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

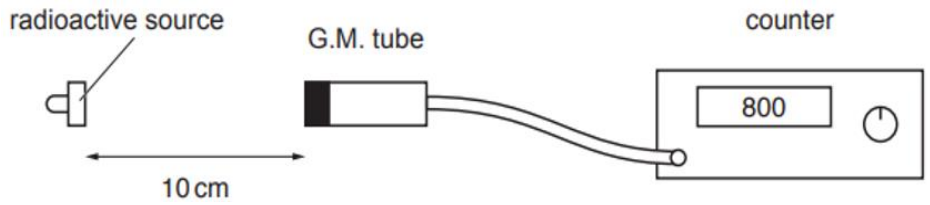


Fig. 8.2

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.

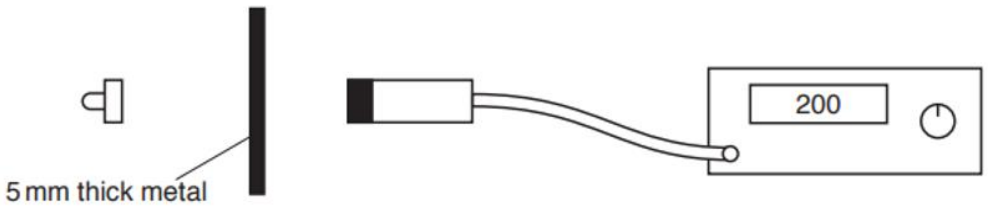


Fig. 8.3

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

……

……

……

…….. [2]

Total: [5]

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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.

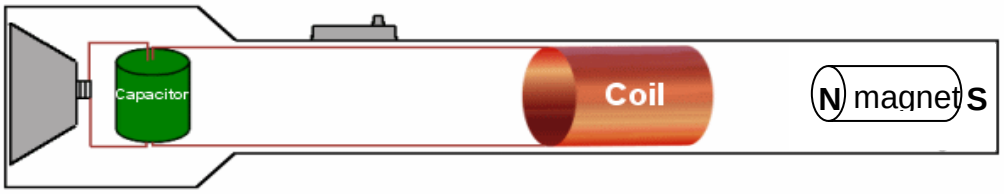


Fig. 9.1

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

……..

……..

……..

……..

……..

……..

…….. [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.

……..

……..

……..

…….. [2]

Total: [5]

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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.

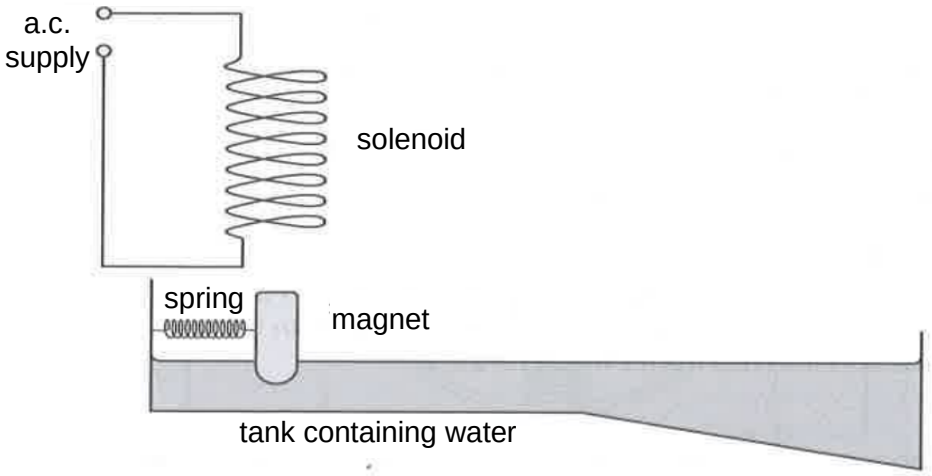


Fig. 10.1

(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.

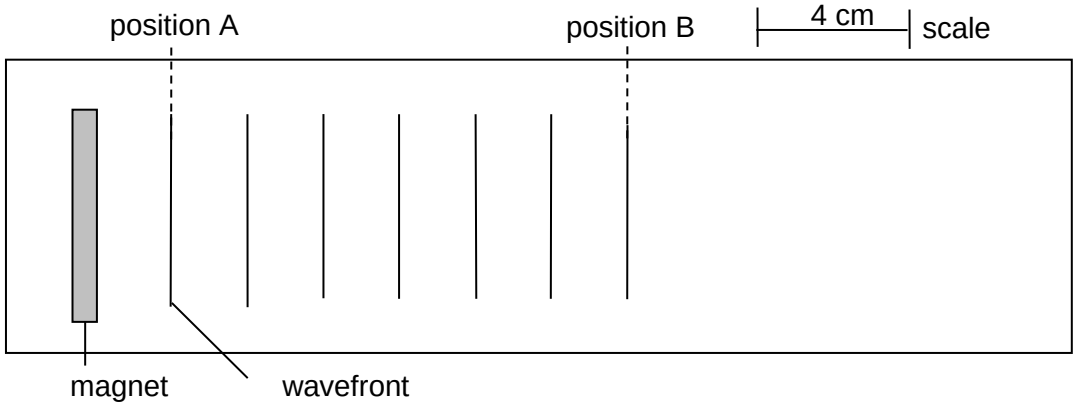


Fig. 10.2 *(drawn to scale)*

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(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.

……..

……..

……..

……..

……..

…….. [3]

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

Total: [10]

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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]

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(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]

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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.

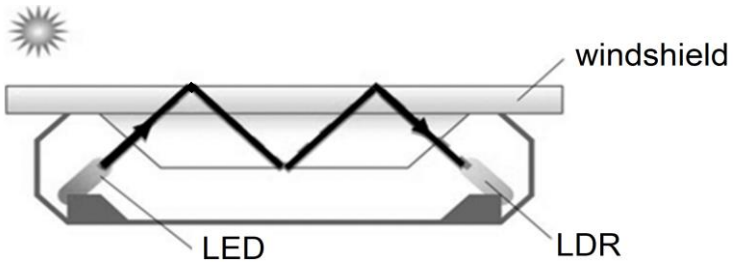


Fig. 12.1

(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.

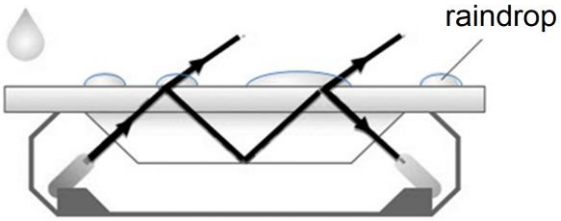


Fig. 12.2

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.

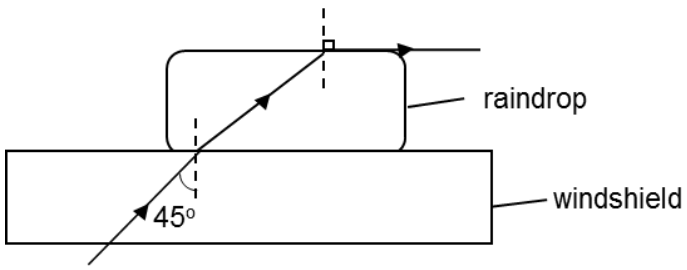


Fig. 12.3

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(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.

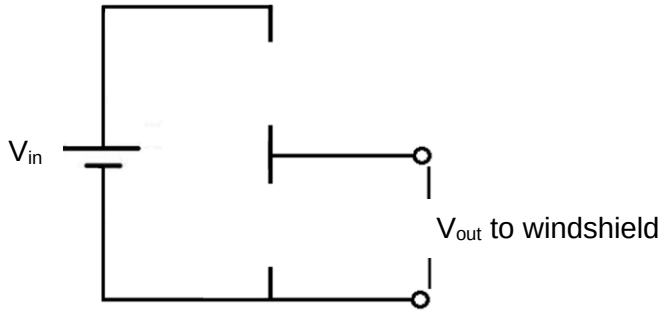


Fig. 12.4

(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.

……..

…….. [1]

Total: [10]

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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.

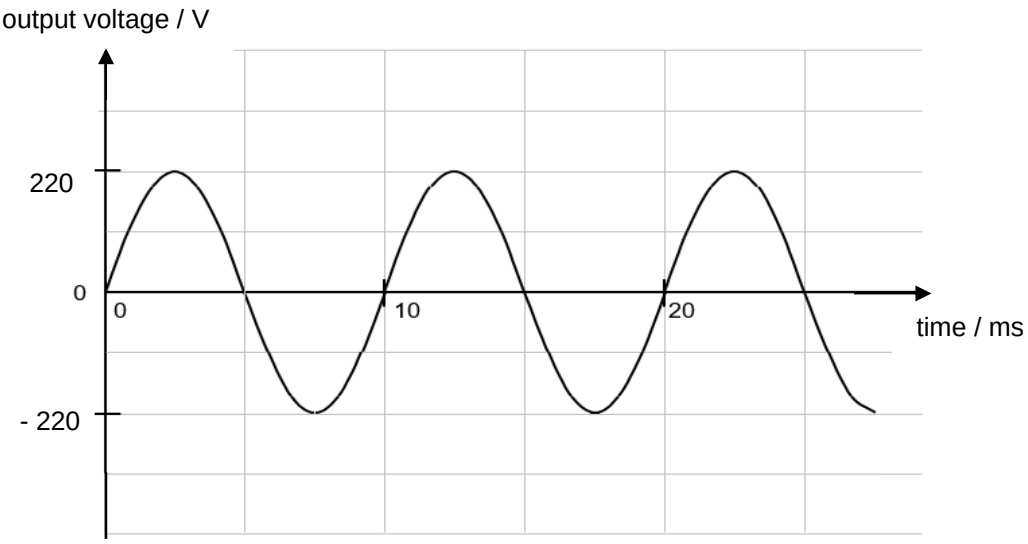


Fig. 13.1

(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.

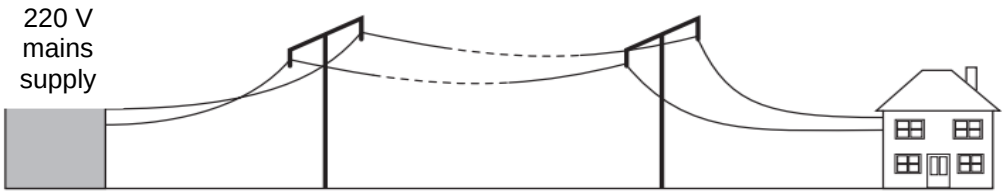


Fig. 13.2

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]

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(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.

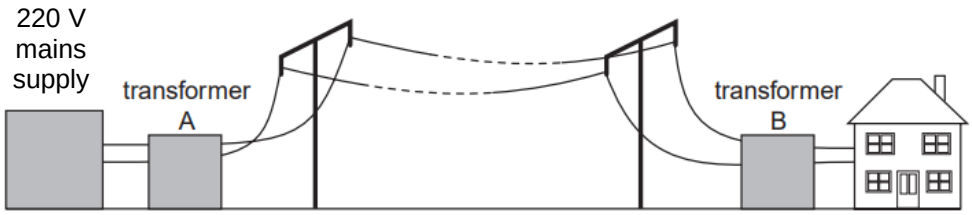


Fig. 13.3

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]

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HUA YI SECONDARY SCHOOL
PRELIMINARY EXAMINATION 2024
SECONDARY 4E (PHYSICS) 6091
MARK SCHEME

Q	Answer	Q	Answer	Q	Answer	Q	Answer
1	D	11	A	21	D	31	B
2	B	12	A	22	B	32	B
3	C	13	D	23	D	33	A
4	C	14	C	24	B	34	C
5	C	15	D	25	C	35	A
6	D	16	A	26	A	36	A
7	B	17	C	27	D	37	A
8	A	18	A	28	C	38	D
9	A	19	A	29	A	39	D
10	C	20	D	30	A	40	D

Section A [50 marks]

Qn No.		Answers	Marks
1	**(a)**	As the **speed increases,** the **air resistance** acting on the child and the sledge also **increases**. Hence the **resultant force decreases** and the **acceleration decreases**. From 24 to 26s, the **forward force is equal to the backward force** and the **resultant force acting on the child and sledge is zero**. Hence, there is **no acceleration** and it **moves with a constant speed**. **Need to mention resultant force in each case to get the marks.**	B1 B1
	(b)	The gradient of the graph becomes zero/ graph become horizontal from t = 24 s to t =26 s. **Need to state the time from t= 24s to 26s to get the mark.**	B1
	(c)	Distance travelled = Area under the graph = ½ x (30-26) x 15.2 = 30.4 m Since the sledge stops in 30.4 m, **it will stop before hitting the wall** which is 35 m ahead.	 M1 A1
	(d)	The energy in the gravitational potential store is transferred to energy in the internal store. OR Gravitational potential energy to thermal / internal energy **Note: the speed is constant, there is no changes in energy in the kinetic store. Reject any answers that mention kinetic store.**	B1
	(e)	The child **experience inertia** where his **body mass resists a change in state of motion** / and **continue to move forward**. **Inertia + resist a change in state of motion / continue to move forward**	B1
		Total:	**[7]**

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2	**(a)**	6.0 s	A1
	(b)	The rebound velocity of 30 m/s is lower/less than the initial velocity. OR The displacement traveled during rebound is less than the initial velocity. **Accept distance instead of displacement.**	B1
	(c)	a = (v-u)/t a = (-40 – 40)/6 a = - 13.3 N/kg g = 13.3 N/kg **Only accept positive gravitational field strength and unit m/s^2 is not acceptable.**	M1 A1
	(d)	The gradient / acceleration is constant so the ball did not reach terminal velocity / is free falling / experience no resistance. **Need to have both.**	B1
		Total:	**[5]**
3	**(a)**	As the **boom angle increases**, the **perpendicular distance between the load and the pivot decreases**. Since the **moment is the product of the force and the perpendicular distance**, a **decrease in the perpendicular distance allows for an increase in the force (load)** while maintaining the same moment. Hence, the maximum load the boom can support increases. **Formula of moments = F x d is needed.**	B1 B1
	(b) (i)	Moment = F x d = 11 500 x 22 = 253 000 Nm	A1
	(b) (ii)	By taking moments about X, Clockwise moments = Anti-clockwise moments 253 000 = W x 5 W = 50 600 N	A1
		Total:	**[4]**
4	**(a)**	mgh = ½ mv^2 gh = ½ v^2 v^2 = 2gh = 2 x 10 x 1 = 20 v = 4.47 m/s	M1 A1
	(b)	Work Done (friction) = mgh – 4.5 J = (4 x 10 x 1) – 4.5 = 35.5 J Work Done (friction) = friction x distance 35.5 = friction x 2 friction = 17.8 N	M1 A1
		Total:	**[4]**

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5	**(a)**	$F_1/A_1 = F_2/A_2$ $5 / 2 = F_2 / 0.08$ $F_2 = 0.2$ N	 M1 A1
	(b) (i)	Mass = Density x Volume = 1 x (0.6 x 2) = 1.2 g	 A1
	(b) (ii)	WD = F x d = 5 x (0.6 x 10^{-2}) = 0.03 J **Need to convert cm to m.**	 A1
	(c)	Volume = Cross sectional area x distance For the same volume of water, since the **cross-sectional area of the nozzle is smaller than the barrel**, the **distance moved by the water at the nozzle must be greater** than the distance moved at the barrel. Hence, the **speed which is the distance moved by the water per second** is greater at the nozzle. **Reject answer that link area to pressure. (0 m)**	B1 B1 B1
		Total:	**[7]**
6	**(a) (i)**	$V_{lamp} = IR = 17.6 \times 10^{-3} \times 10 = 0.176$ V $V_{thermistor} = 1.5 - 0.176 = 1.32$ V	M1 A1
	(a) (ii)	$R_{thermistor} = V/I = 1.32 / (17.6 \times 10^{-3}) = 75\ \Omega$ Temperature = 40 °C **Allow full ecf**	M1 A1
	(b)	In convection oven, the **heat is transferred from the hot air to the food via conduction**. Since **air is a poor thermal conductor**, the rate of cooking food is slower. In infra-red toaster, the **heat is transferred directly to the food using infra-red radiation at high speed**. Hence, food is cook faster. **1 m – air is a poor thermal conductor** **1 m – infra-red radiation travels at high speed.**	B1 B1
		Total:	**[6]**
7	**(a)**	Lamp A Tungsten wire has a **higher reisistivity** and a coil filament is **longer** compared to uncoil one, hence **resistance of lamp A is higher**. **No marks for Lamp A**	 B1 B1
	(b)	When the lamps are connected in series, the **effective resistance of the circuit increases**. / **the voltage across each lamp is lower.** Hence the **current passing through the lamps decreases** / **The emf is shared between the lamps**. **Temperature of the lamp decreases** and the **resistance of the lamp is lower** as it is a non-ohmic conductor. **To get the last mark, need to link back to lamp being non-ohmic.**	B1 B1 B1

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	(c)	The **fuse will still melts/blows** and the **lamp appears off**. However, the metal case is still live and can cause **electrocution or shock** **Many did not mention about the lamp not working and so was not awarded 2 m.**	B1 B1
		Total:	**[7]**
8	**(a)**	At least 3 points plotted at (6000, 800), (12000, 400), (18000, 200) and (24000, 100) Smooth curve drawn	B1 B1
	(b)	9600 years (Answers depend on graph) **Unit must be stated.**	B1
	(c)	β particles are absorbed by the 5 mm thick metal causing a significant decrease in the count rate. Y-radiation is able to pass through the metal, thereby still causing a count rate of 200 with the metal piece in place.	B1 B1
		Total:	**[5]**
9	**(a)**	Lenz's law state that the **direction of the induced current is such that its magnetic effect opposes the motion or change producing it.** When the **magnet approaches the solenoid**, the **current induced in the solenoid will flow in a direction to repel the incoming magnet.** Similarly, when the **magnet is leaving the solenoid**, the **current induced in the solenoid will flow in the opposite direction to attract the leaving magnet**. This generates an alternating current. **Reject 1 m if the Lenz's law is stated incorrectly such as the direction of the induced current opposes the changes that produces it.**	B1 B1 B1
	(b)	The movement of the **magnet causes the surrounding air to be displaced**. Sound then **travels in the form of a longitudinal wave**, consisting of a **series of compression and rarefaction.** Sound **energy is transferred from particles to particles through vibration** until it reaches the person's ear.	B1 B1
		Total:	**[5]**
10	**(a)**	When the switch is closed, an alternating current flow through the solenoid causing the **solenoid to be magnetized with alternating poles attracting and repelling the magnet.** When the magnet vibrates, it creates **disturbances on the water surface**, forming waves. **Need to mention disturbances / vibrate periodically / repeatedly to get the 2nd mark.**	B1 B1

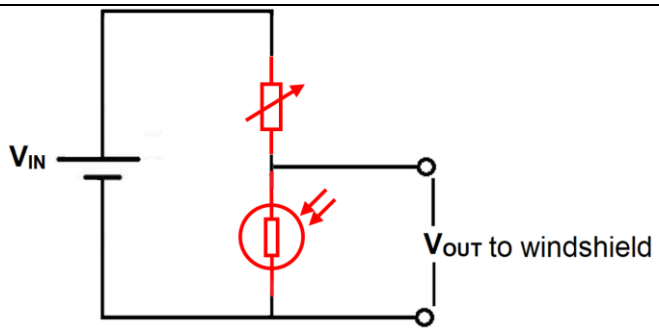
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	(b)	Increase the number of turns of the solenoid / Increase the e.m.f of the a.c supply / insert a soft iron core into the solenoid. **Reject incorrect phrasing: Increase number of coils.**	B1
	(c) (i)	A wavefront is an imaginary line representing the points of a wave that are in phase.	B1
	(c) (ii)	Speed = Distance / Time = (4 x 3) / 4s = 3.0 cm/s **Reject wrong unit: m/s.**	A1
	(c) (iii)	6 waves in 4 s 6/4 waves in 1 s frequency = 6/4 = 1.5 Hz **Reject wrong / no unit**	A1
	(d)	The amplitude decreases as it moves from shallow to deeper water because energy is lost to the surround water molecules as it moves away from the source (vibrating magnet) to the other end. The frequency of the waves remains the same in both the shallow and deep ends as the frequency of a wave is determined only by the source of the vibration (the vibrating magnet). Using the formula v = fλ, as the speed of the wave increases when it moves from shallow to deeper water, the wavelength of the wave also increases. **Need to elaborate on why amplitude decrease, frequency stay the same and wavelength increases for each mark.**	B1 B1 B1
	(e)	The wavefronts are further away.	B1
		Total:	**[10]**
11	**(a) (i)**	E = Pt = 2000 x (2 x 60+38) = 316 000 J	A1
	(a) (ii)	Energy output = mcθ + ml_v = 0.75 x 4200 x (100 – 25.5) + (0.01 x 2260 x 10^3) = 257275 J Efficiency = energy output / energy input x 100% = 257275 / 316000 x 100% = 81.4% **No marks if the energy required to boil of 0.01 kg of water is not added.**	M1 A1
	(b) (i)	The temperature remains constant at 0 °C when shaved ice melts because the **energy absorbed is used to increases the internal potential energy to overcome the forces of attraction between water molecules,** changing the ice from solid to liquid.	B1 B1

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		This process **does not increase the internal kinetic energy of the molecules, so the temperature remains constant** until all the ice has melted.	
	(b) (ii)	Energy output = ml_f = (800 – 11.2) x 334 x 10^3 = 263459.2 J Efficiency = energy output / energy input x 100% = 263459.2 / 316000 x 100% = 83.3%	M1 A1
	(b) (iii)	The temperature difference is lower between 0 °C and room temperature as compared to 100 °C and room temperature. So the rate of thermal energy transfer with surrounding is lower. **Reject answer such as less energy transfer with surrounding without elaboration / latent heat of fusion is lower.**	B1
	(c)	As the **temperature increases**, the water vapor **gains kinetic energy and collide with the walls of the kettle more frequently and more forcefully**. As the **water boils**, the **amount of water vapor in the kettle also increases which adds to the frequency of collision of water vapor with the kettle's wall**. Thus, a **larger average force is exerted over the surface area** of the kettle causing an increase in pressure. **1 m – gain K.E, frequency and force of collision with walls increases** **1 m – amount of water vapour increases, frequency of collision with wall increases.**	B1 B1
		Total:	**[10]**
Section B [10 marks]			
12	**(a)**	As light is travelling from an **optically denser medium (glass) to an optically less dense medium** (air) and the **angle of incidence is greater than the critical angle**, the infrared light undergoes **total internal reflection** at the boundary between the windshield and the air.	B1 B1
	(b)	n_{water} = sin i_{air} / sin r_{water} n_{glass} = sin i_{air} / sin r_{glass} Using the 2 formulas, n_{water} / n_{glass} = sin r_{glass} / sin r_{water} For total internal reflection, r_{water} = 90°, 1.33 / n_{glass} = sin r_{glass} / sin 90 n_{glass} = 1.33 / sin r_{glass} Given that r_{glass} = 45° < c (not total internally reflected) n_{glass} < 1.33 / sin 45 n_{glass} < 1.88 (shown)	M1 M1 A1
	(c) (i)	Positions of variable resistor and LDR Symbols for variable resistor and LDR	B1 B1

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	(c) (ii)	On rainy days, **less light is detected by the LDR**. This causes the **resistance of the LDR to increase**. Thus the **potential difference V_{OUT} increases**, turning on the wiper.	B1 B1
	(d)	Variable resistor is able to vary the output voltage to the windshield wiper. / It can adjust the amount of rain / light that will cause the wipers turn on.	B1
		Total:	**[10]**
13	**(a) (i)**	$1/(10 \times 10^{-3}) = 100$ revolutions per second	A1
	(ii)	2.5 ms **Reject wrong / no unit**	A1
	(iii)	Amplitude and frequency is also halved.	B1
	(b)	As the wire is very long, the resistance of the wire is high. The current in the cable is large too. By $\underline{P = I^2R}$, the loss of power as heat by the wire is large and thus less power is supplied to the lamps. OR As the wire is very long, the resistance of the wire is high. Thus, the voltage across the wire is large, causing the voltage across the lamps to be much less than 230 V. Hence, by $\underline{P = V^2/R}$, the power given by the lamp is little/lamps are dim. **Formula is required to get the 2nd mark.**	B1 B1 B1 B1
	(c) (i)	Comparing the voltages of primary coil to secondary coil: Step down ratio = 3 300: 220 = 15 : 1 Hence the coils must be step down to the same ratio of 15 : 1 Comparing the turn ratio, Coil M : Coil K = 1 500 : 100 = 15 : 1	B1 A1
	(c) (ii)	Input power = 100 / 75 x 15 kW = 20 kW I = P / V = 20 000 / 3 300 = 6.1 A	M1 A1

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	(c) (iii)	Laminating the iron core reduces the power loss due to heat produced by eddy currents OR Using low resistance (primary and secondary) coils will minimize the amount of heat produced in the coils. OR Increase the magnetic flux linkage between the primary and secondary coils by using a soft magnetic material (iron core) to link **Need to have the correct elaboration of how each one work. Reject answer that just state use thick wire with lower resistance / use laminated iron sheet / insert soft iron core.**	B1
		Total:	**[10]**

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