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CHRIST CHURCH SECONDARY SCHOOL
2024 PRELIMINARY EXAMINATION
FOUR EXPRESS

CANDIDATE NAME		CLASS	
CENTRE NUMBER	S	INDEX NUMBER	

PHYSICS **6091/01**
Paper 1 **27 Aug 2024**
1 hour

Additional Material: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST
Write in soft pencil on the Multiple Choice Answer Sheet.
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 in this section. 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 Multiple Choice Answer Sheet provided.

Read very carefully the instructions on the answer sheet.

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 calculator is expected, where appropriate.

This Question Paper consists of 18 printed pages including this cover page.

[Turn over

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1 Which of the following shows the most suitable instruments used for the measurements of these given objects?

	internal diameter of a test-tube	thickness of a copper wire
A	digital calipers	digital micrometer screw gauge
B	metre rule	digital calipers
C	digital micrometer screw gauge	digital calipers
D	measuring tape	digital micrometer screw gauge

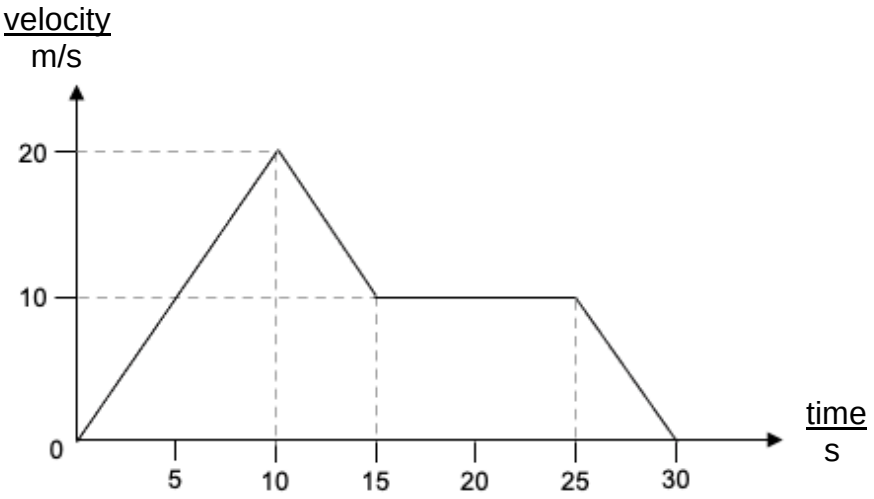
2 A student studies some equations:

density = mass / volume
work done = force x displacement
acceleration = change of velocity / time taken

How many different vector quantities can be found in these equations?

A 2 **B** 3 **C** 4 **D** 5

3 The velocity-time graph shows the motion of an object during a period of 30 s.



What is the average velocity of the object during this first 25 s?

A 10 m/s **B** 11 m/s **C** 17 m/s **D** 18 m/s

4 A cyclist has an initial speed of 5.0 m/s. She is travelling at a uniform deceleration for 3.0 m before she came to a stop.

How long did she take to stop?

A 0.60 s
B 1.2 s
C 1.3 s
D 3.0 s

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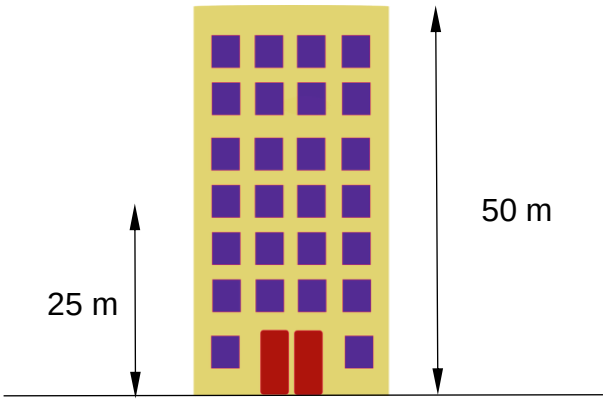
5 Two similar balls are released from a 50 m tall building at the same time.

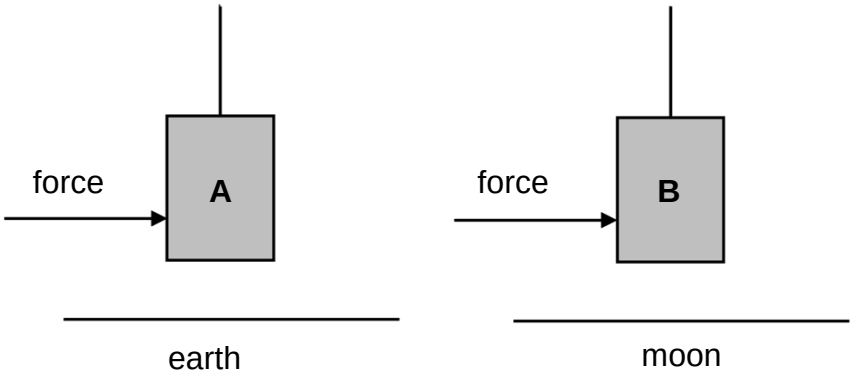


One drops from the top while the other from mid-level. Air resistance is negligible.

Which quantity is the same for both balls?

A acceleration **B** average speed **C** final velocity **D** time of travel

6 Two identical blocks of concrete, A and B are hung on a rope close to the surface of Earth and the surface of the moon as shown.



A sideway force of same magnitude is applied to both blocks of concrete.

What statement is correct?

A It is easier to move B as it has less weight.
B It is more difficult to move A as it has less weight.
C Both A and B move with the same ease as they have the same mass.
D Both A and B move with the same ease as they have the same weight.

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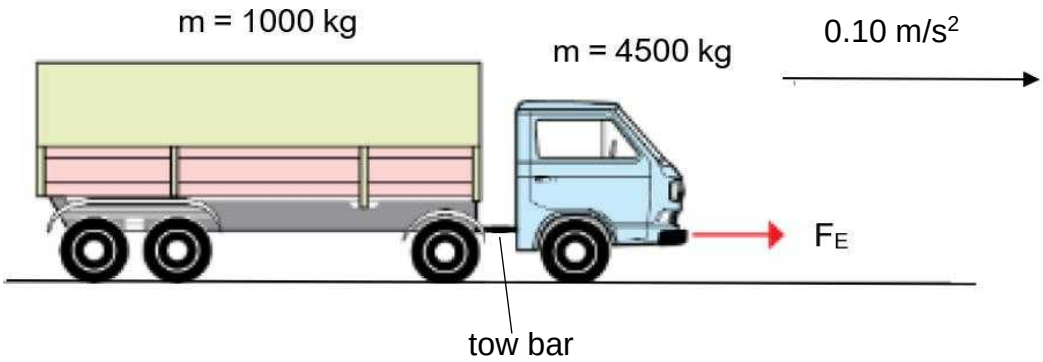
7 A truck engine of mass 4500 kg pulls a trailer of mass 1000 kg along a level track is accelerating at 0.10 m/s^2. The truck engine is connected to the trailer via a tow bar.

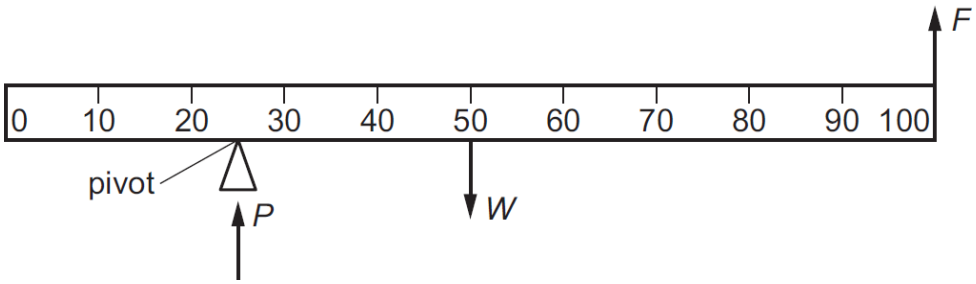


Given that the resistive force acting on the truck engine is 10 N per 1000 kg and the resistive force acting on the trailer is 5 N per 1000 kg.

What are the forward thrust F_E exerted by the engine and the tension in the tow bar?

	forward thrust F_E	tension in tow bar
A	550 N	0 N
B	550 N	105 N
C	600 N	0 N
D	600 N	105 N

8 A uniform metre rule of weight *W* is pivoted at the 25 cm mark and held horizontal by a force F applied upwards at the 100 cm mark.



The rule is supported by a vertical force *P* acting at the pivot.

What is the magnitude of *P*?

A $\frac{1}{3}W$ **B** $\frac{1}{2}W$ **C** $\frac{2}{3}W$ **D** $\frac{4}{3}W$

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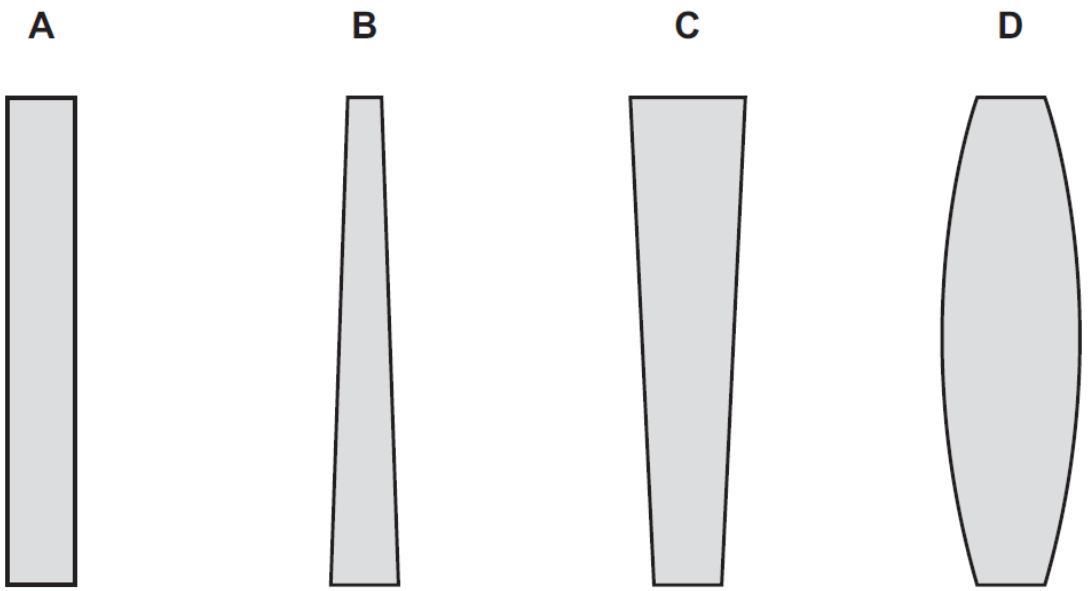
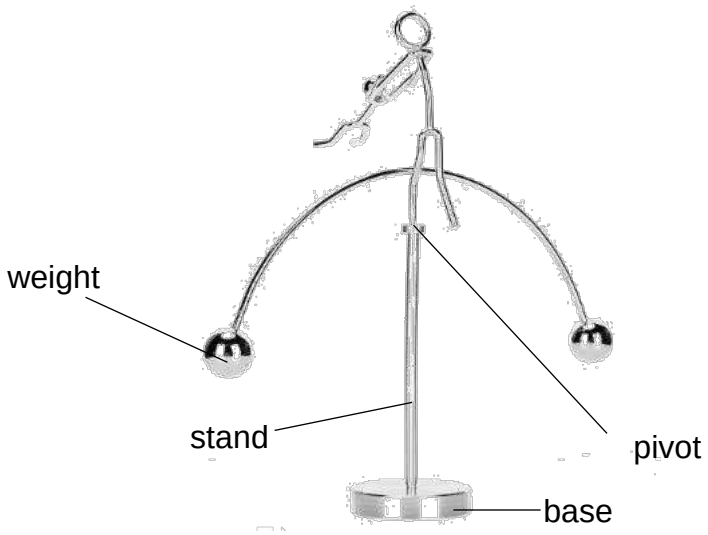
9 Four glass objects have square bases of equal area.

Which object is the most stable?



10 A balancing toy comprises two weights on each side as shown.
It is pivoted at the top of a stand with a base.



Which statement concerning the centre of gravity (CG) of balancing toy is correct?

A If titled and released, the CG of the toy would not oscillate sideways.
B The base raises the CG of the toy to provide stability.
C The thin stand raises the CG of this toy to provide stability.
D The two weights lower the CG of this toy to below the pivot to provide stability.

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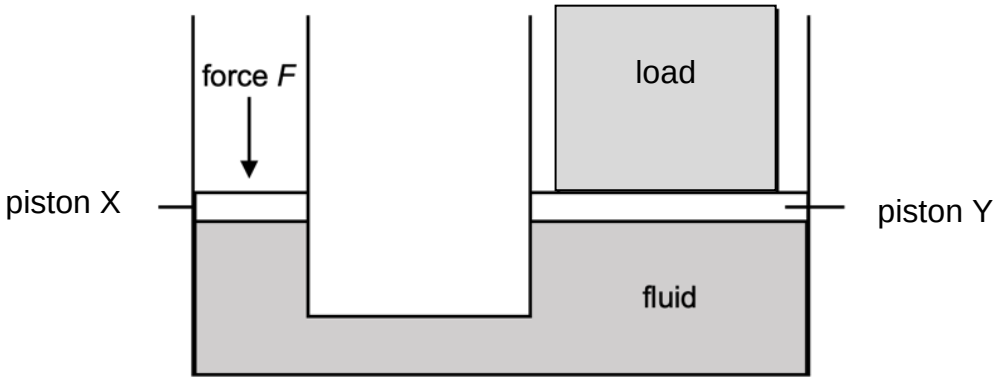
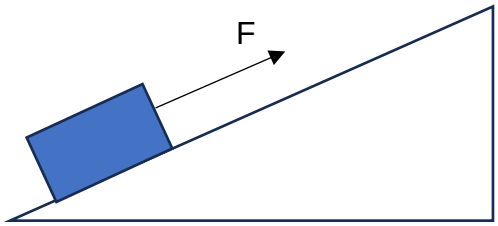
11 A simple hydraulic jack is used to lift a load by applying a force F as shown.



Which changes to the diameters of the pistons X and Y would allow a greater load to be lifted by the same force, *F*?

	diameter of piston X	diameter of piston Y
A	doubled	doubled
B	doubled	halved
C	remained the same	halved
D	halved	doubled

12 A box is pulled up with a force F up a rough slope at a uniform speed.



Which statement regarding the energy stores of the box is **not** correct?

A Mechanical work is done by the force F on the object as it moves up the slope.
B No energy is transferred out to the surrounding due to heating.
C The gravitational potential store of the box increases as it moves up the slope.
D The kinetic store of the box remains the same as it moves up the slope.

13 Which statement correctly describes the kinetic particle model in liquid during boiling?

A The average speed of the particles increases.
B The intermolecular forces of attraction between the particles become weaker.
C The internal kinetic energy of the particles increases.
D The internal potential energy of the particles decreases.

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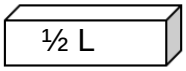
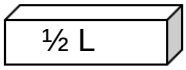
14 Four bars of different made of different materials and different sizes are placed at one end of each bar in water at 80 °C.

The time taken for the temperature to rise by 2 °C on the other end of the bars are recorded.

material	size	time for temperature to rise by 2 °C / s
aluminium		12
copper		3
fibreglass		77
polystyrene		15

The materials are being considered to make a metal tank to keep its contents warm. The metal tank will be insulated.

Which materials should be used to make the tank and its insulation?

	tank	insulation
A	aluminium	fibreglass
B	aluminium	polystyrene
C	copper	fibreglass
D	copper	polystyrene

15 A block of brass is heated and its rise in temperature is measured.

The amount of energy gained by the block is E. The mass of the block is m.
The rise in temperature of the block is ΔT.

Which expression gives the specific heat capacity of brass?

A $\dfrac{m}{E\Delta T}$

B $\dfrac{m\Delta T}{E}$

C $\dfrac{E}{m\Delta T}$

D $\dfrac{E\Delta T}{m}$

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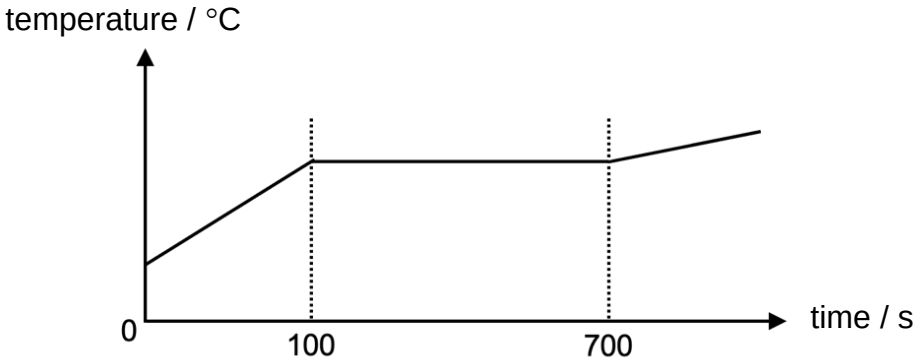
16 A 550 g of unknown liquid is heated using a 1.5 kW electric heater.

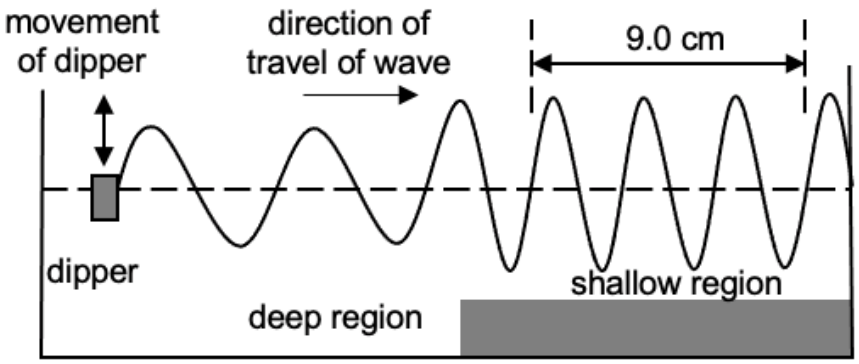
The temperature of this liquid over a period time is plotted on a graph shown below.



What is the specific latent heat of vaporisation of the substance?

A 1.6 J/kg
B 270 J/kg
C 1600 J/kg
D 1900 kJ/kg

17 A dipper vibrates at a frequency of 2.5 Hz in a ripple tank to produce water waves. The wave travels from the deep region to the shallow region as shown.



Which statement is correct?

A The frequency of the waves increases as it moves from deep to shallow regions.
B The speed of the waves in the shallow region is approximately 23 cm/s.
C This wave is longitudinal as vibration is perpendicular to direction of wave travel.
D Wavefronts are close together in the shallow region as compared to the deep region.

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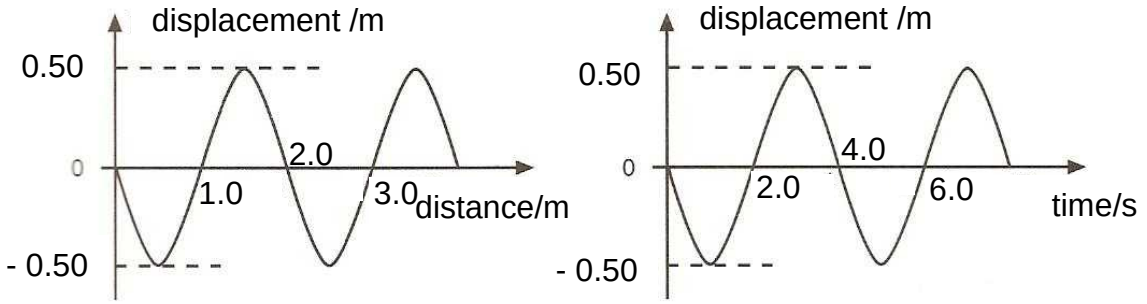
18 The graphs below represent the variations in the displacement of a sinusoidal wave with distance and time.



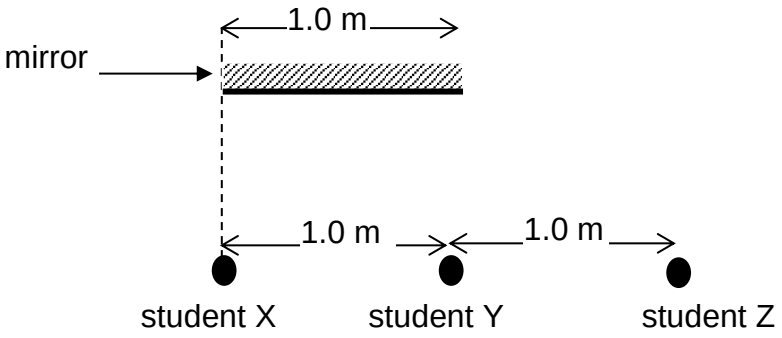
Which row correctly gives the value of the wavelength, amplitude, frequency and speed of this wave?

	wavelength/m	amplitude/m	frequency/Hz	speed/(m/s)
A	1.0	- 0.50	4.0	4.0
B	1.0	0.50	2.0	4.0
C	2.0	0.50	0.25	0.50
D	2.0	1.00	0.25	0.50

19 Which statement best describes the hazardous effects due to over-exposure to electromagnetic waves?

A The exposure to X-rays can cause heating effects which is harmful to the skin.
B The infrared waves can result in ionising radiation that penetrate human body.
C The over-exposure to radio waves can potentially cause skin cancer.
D The radioactive materials can potentially emit gamma rays to ionise living cells.

20 Three students, X, Y and Z, stand 1.0 m apart in front of a plane mirror that is 1.0 m long.



Student X stands in line with one edge.

How many students can see the images of the other two?

A 0 **B** 1 **C** 2 **D** 3

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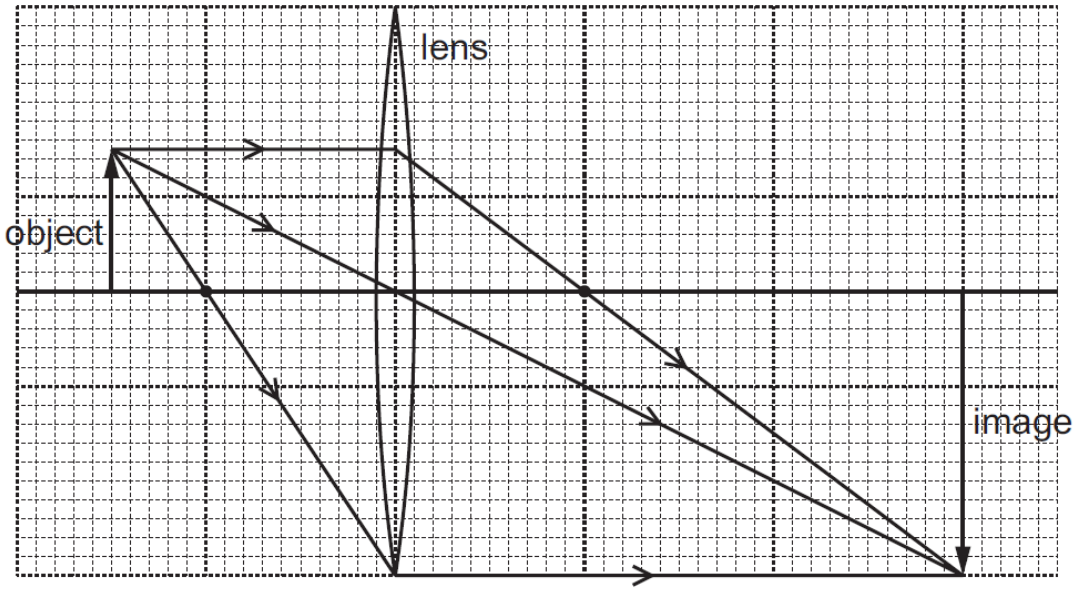
21 An object is placed in front of a converging lens of focal length 4.0 cm.
The height of the image is 6.0 cm.

The arrangement is shown on the scale diagram.

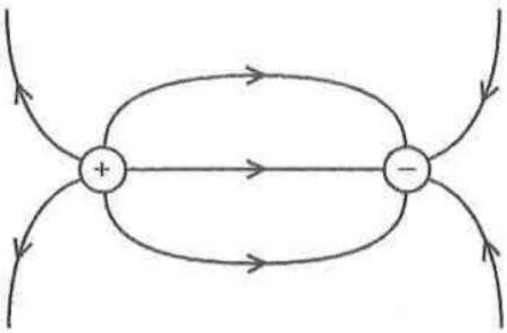


Which statement is **not** correct?

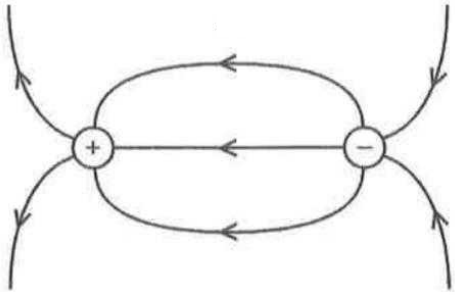
A The image shown can be described as real and inverted.
B The linear magnification of produced by the lens is 0.50.
C When object is placed 3.0 cm from lens, image formed is upright and magnified.
D When object is placed 8.0 cm from lens, the image is same size as object.

22 Which diagram shows the electric field between a positive point charge and a negative point charge?

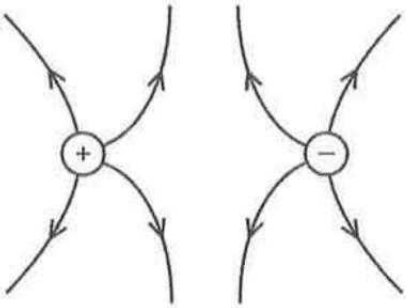
A



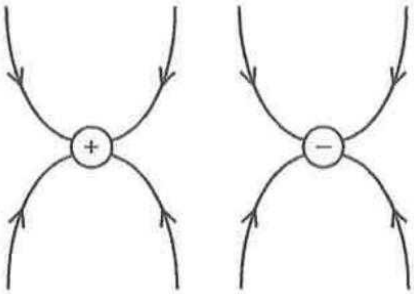
B



C



D



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23 Which example does **not** describe how electrostatic charging may be a potential hazard?

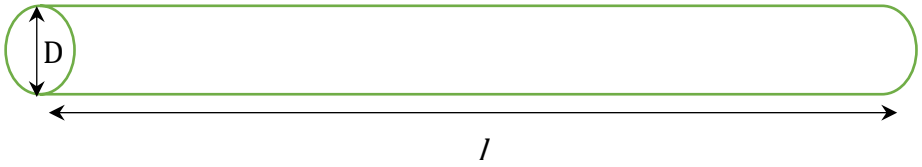
A Accumulation of charges on the walls of ungrounded truck carrying petrol.
B Bulk transfer of combustible fuel in pipes can generate charges through friction.
C Built-up static charges on surface of airplanes during mid-air refuelling.
D Use of charged paint droplets to create a uniform coat on metallic surface of car.

24 During a thunderstorm, 35 C of charge passes between the thunderclouds and the ground. On average, a lightning can strike the ground for 1.0 ms.

What is the average current generated between the thunderclouds and the ground when the lightning strikes?

A 35mA
B 35 A
C 35 kA
D 35 MA

25 A resistance wire of length l and diameter D has a resistance R.



Which change will cause the resistance of another wire of the same material to increase four times?

A Decrease the diameter to $\frac{\mathrm{D}}{2}$ and keep the length unchanged
B Decrease the diameter to $\frac{\mathrm{D}}{2}$ and decrease the length to $\frac{l}{2}$
C Increase the diameter to $2\mathrm{D}$ and decrease the length to $\frac{l}{2}$
D Increase the diameter to $2\mathrm{D}$ and decrease the length to $4l$

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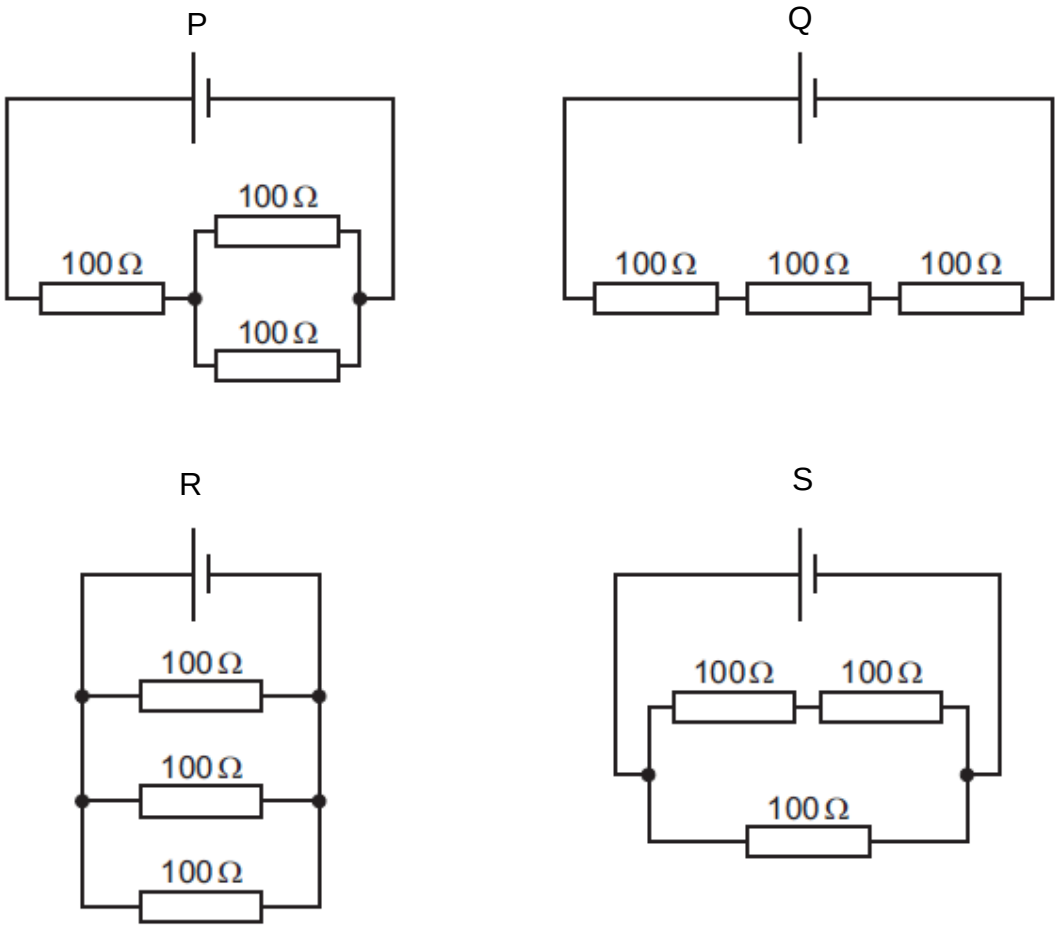
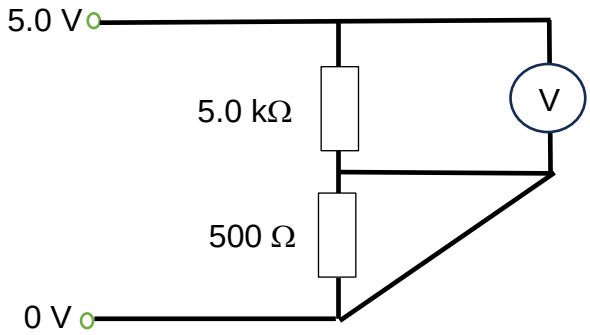
26 The diagrams show four circuits. Each circuit contains three 100 Ω resistors.



Which row correctly arranges the total resistance of the circuit from smallest to largest?

	smallest total resistance → largest total resistance
A	P, Q, R, S
B	R, P, S, Q
C	R, S, P, Q
D	Q, R, P, S

27 A voltmeter is connected across a potential divider circuit as shown.



What is the reading on the voltmeter?

A 0.00 V **B** 0.45 V **C** 4.55 V **D** 5.00 V

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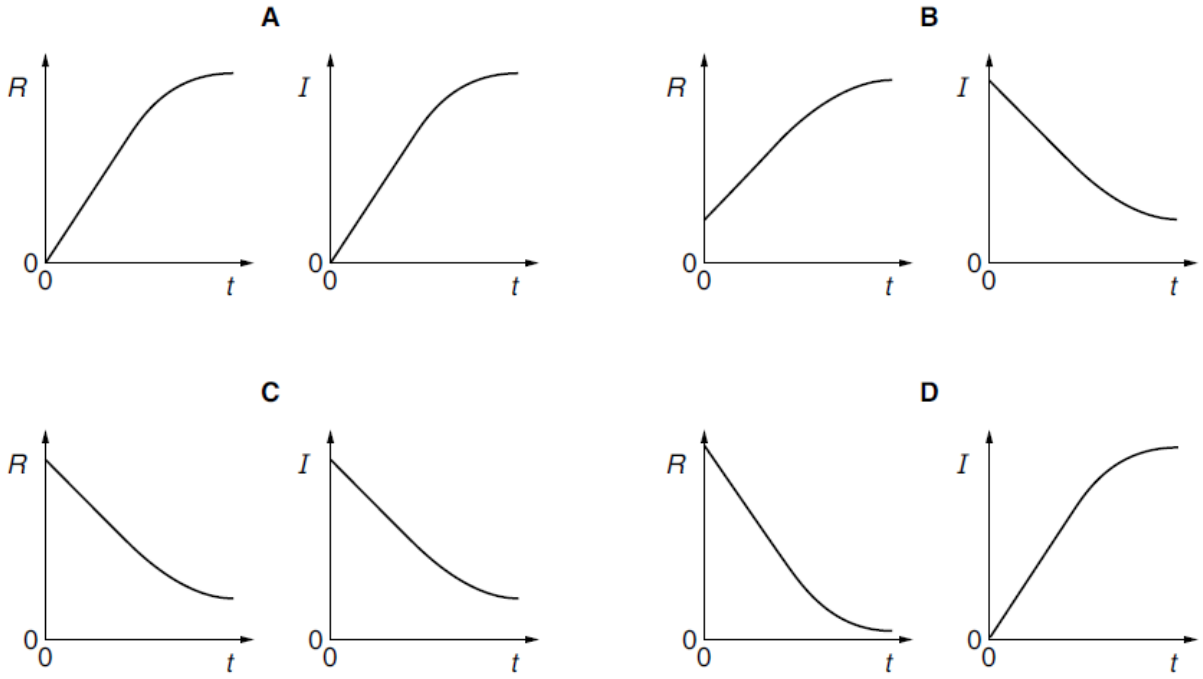
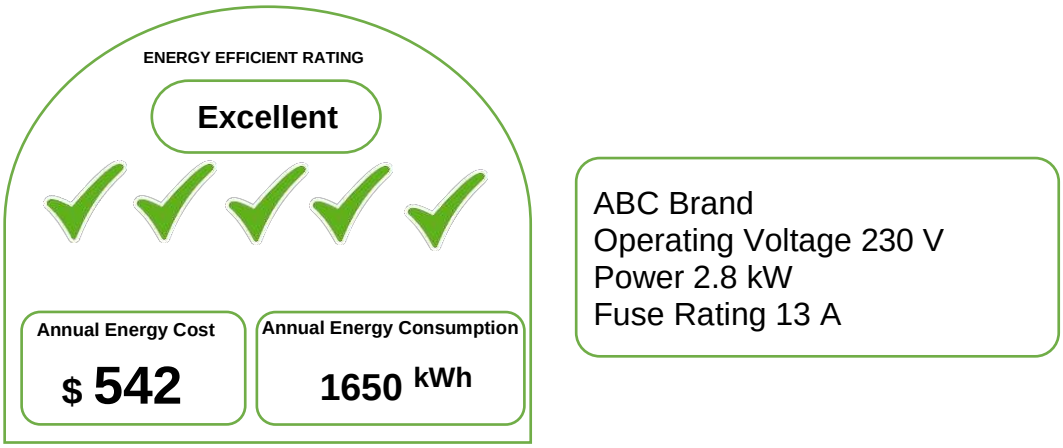
28 When a filament lamp is switched on, there is a current in filament.

As the temperature of the filament increases, its resistance changes.

Which pair of graphs shows how the resistance R of the filament and the current I in the lamp vary with time t after the lamp is switched on?



29 Two labels are found on an electrical appliance.



Which of the statement is **not** correct?

A The annual unit cost of electricity is about $0.328.
B The operating current is 13 A.
C The total energy consumption per year is 5.94 GJ.
D When operating for 4.0 minutes, the amount of electrical energy used is 672 kJ.

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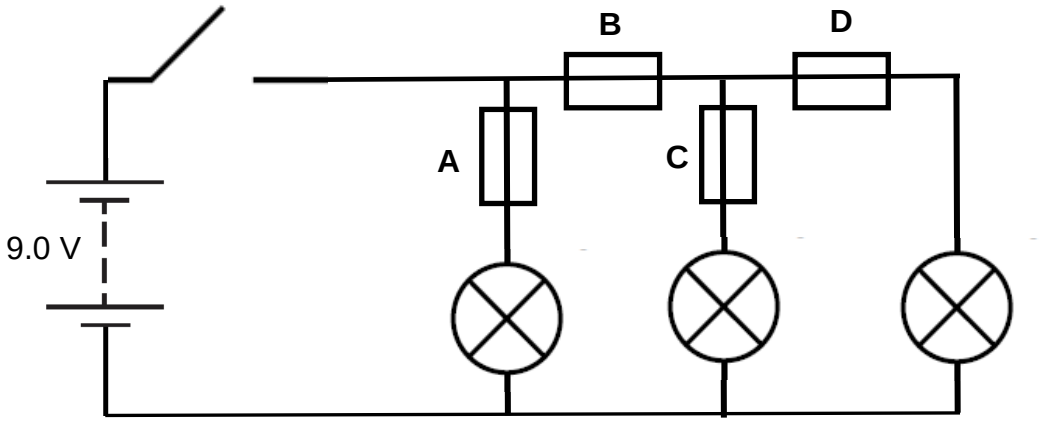
30 Which row shows the correct colour code for wiring in a three-pin plug.

	earth wire	live wire	neutral wire
A	brown	blue	green/yellow
B	blue	green/yellow	brown
C	blue	brown	green/yellow
D	green/yellow	brown	blue

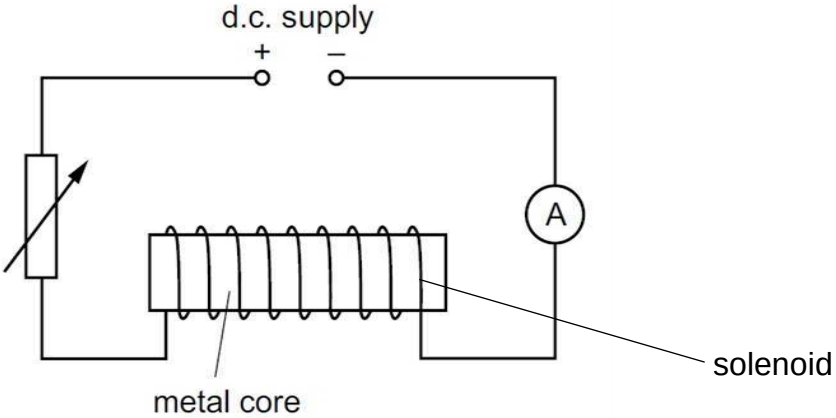
31 Three light bulbs each rated 9 V, 40 W are connected to a 9.0 V battery.

Four fuses, A, B, C and D are also connected as shown. Each fuse is rated 5A.

Which fuse will melt when the switch is closed?



32 The diagram shows an electromagnet.



Which row correctly shows the materials used for the different parts of the electromagnet?

	metal core	solenoid
A	copper	soft iron
B	soft iron	copper
C	soft iron	soft iron
D	steel	steel

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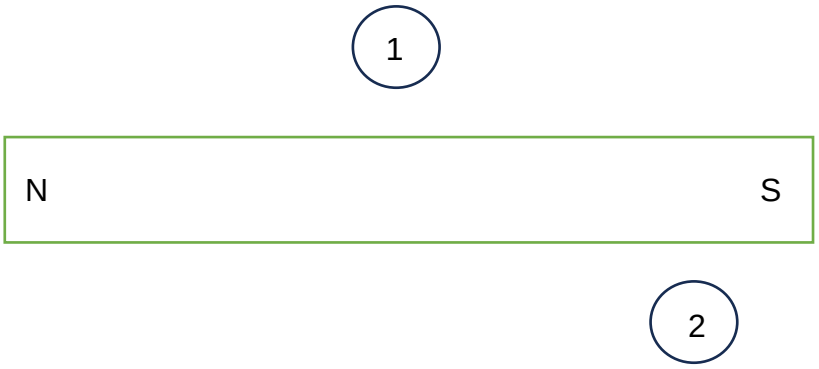
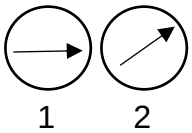
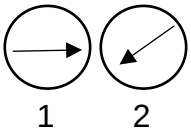
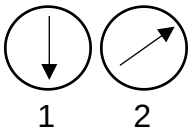
33 Two plotting compasses are placed besides a permanent bar magnet.

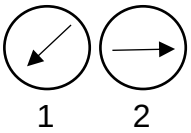


In which directions do the two compasses point?

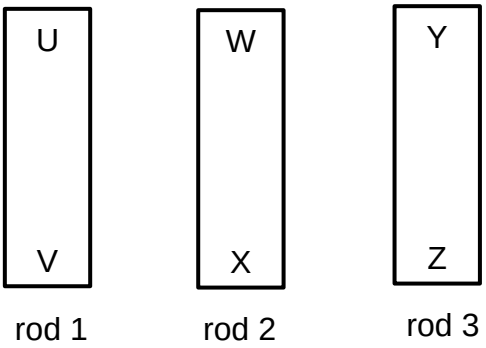
A 

B 

C 

D 

34 The ends of three metal rods are tested by holding close to one another.



The results are recorded:

end U attracts end W
end V attracts end X
end X repels end Y
end Z attracts end U

Which statement is not correct?

A Ends U and Y have the same polarity.
B Ends V and Z have same polarity.
C Rods 1, 2 and 3 are all magnets.
D Rods 1 and 2 are not magnets as there is no repulsion recorded between them.

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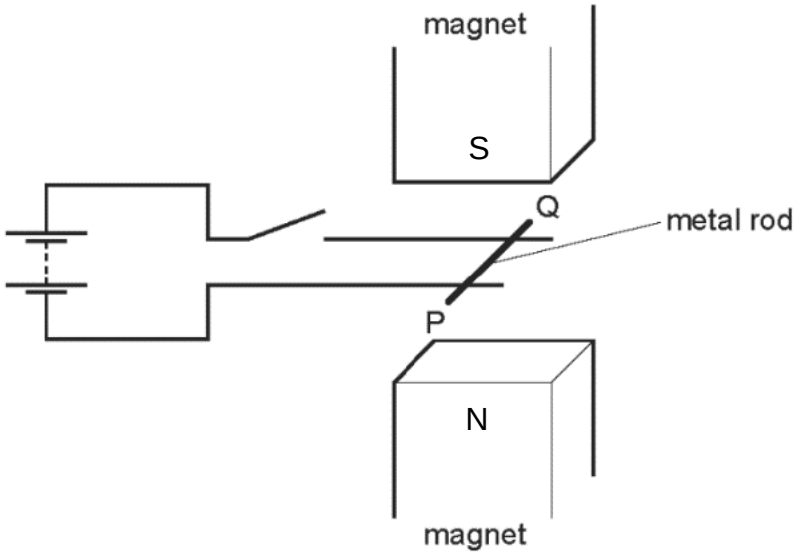
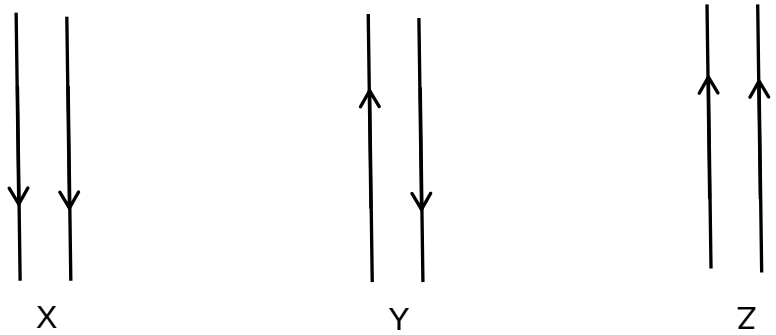
35 A metal rod PQ rests on two horizontal metal wires connected to a battery. The rod lies between the poles of a magnet.



Which of the change(s) can be made to move the rod to the right when the switch is closed?

A Repeatedly open and close the switch.
B Reverse the battery terminals only. (Positive and negative positions)
C Reverse the battery terminals and positions of the north and south poles.
D Reverse the direction of the metal rod. (P and Q change positions)

36 Three pairs of parallel wires have currents flowing through them as shown.



What type of force does each pair of wires experience?

	X	Y	Z
A	attraction	repulsion	attraction
B	attraction	repulsion	none
C	repulsion	none	attraction
D	repulsion	attraction	repulsion

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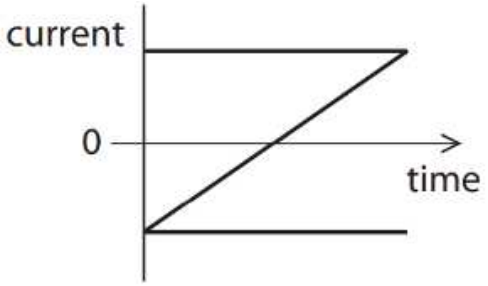
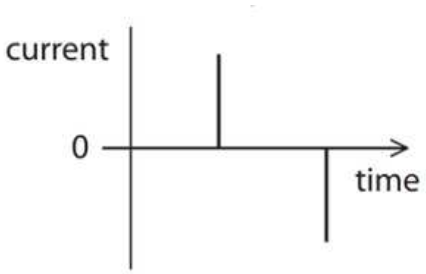
37 A student connects a switch, a fixed resistor and a battery to the primary coil of a step-up transformer. The student also connects a fixed resistor across the secondary coil. The student switches on the circuit and then later switches it off.

Which of the following graphs represent the current in the secondary coil?

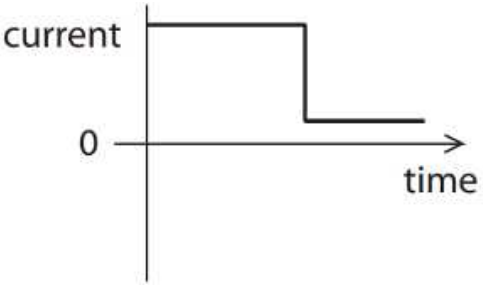
A



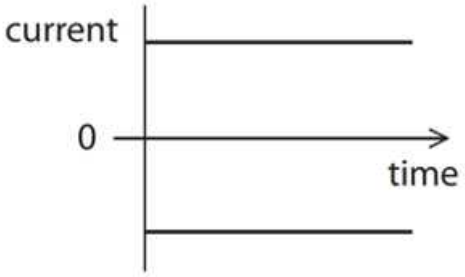
B



C



D



38 A charger for a mobile phone uses a transformer which steps the voltage down from 230 V to 5.0 V.

The secondary coil in the transformer has 100 turns.

How many turns are on the primary coil?

A 2 **B** 12 **C** 4600 **D** 530 000

39 Electric power cables transmit electrical energy over large distances using high-voltage alternating current.

What are the advantages of using high voltage and of using an alternating current?

	advantage of using a high voltage	advantage of using an alternating current
A	high current is produced in the cables	resistance of the cable is reduced
B	high current is produced in the cables	voltage can be varied using a transformer
C	less energy is wasted in the cables	resistance of the cable is reduced
D	less energy is wasted in the cables	voltage can be varied using a transformer

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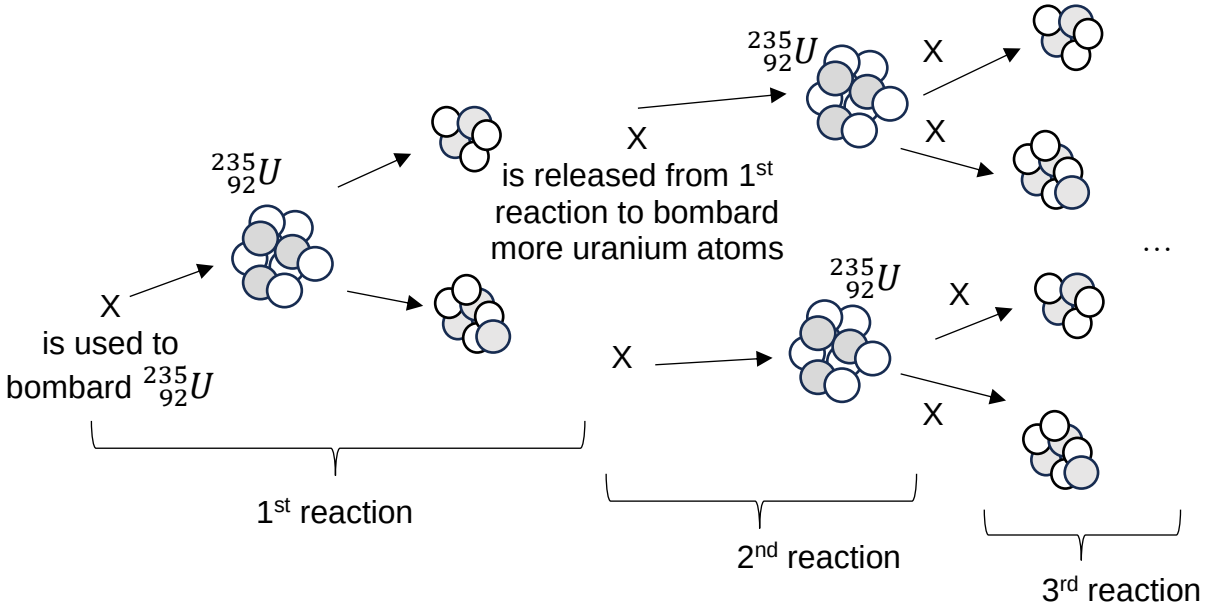
40 A chain reaction of a nuclear fuel of Uranium, $^{235}_{92}U$ is shown below.



Which nuclear reaction is taking place and what is the particle marked X?

	nuclear reaction	particle X
A	alpha decay	alpha particle
B	fission	beta particle
C	fission	neutron
D	fusion	gamma rays

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CHRIST CHURCH SECONDARY SCHOOL
2024 PRELIMINARY EXAMINATION
FOUR EXPRESS

CANDIDATE NAME		CLASS	
CENTRE NUMBER	S	INDEX NUMBER	

PHYSICS **6091/02**
Paper 2 **20 Aug 2024**
1 hour 45 minutes

Candidates answer on the Question Paper
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST
Write your name, class register number and class in the spaces provided at the top of this paper and all the work you hand in.
You may use an HB pencil for any diagrams, 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.

Students are reminded that **all** quantitative answers should include appropriate units.
The use of approved scientific calculator is expected where appropriate.
Students 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 Question Paper consists of **22** printed pages including this cover page.

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Section A

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

1 Fig. 1.1 shows a CHRian stationary on a Zipline.

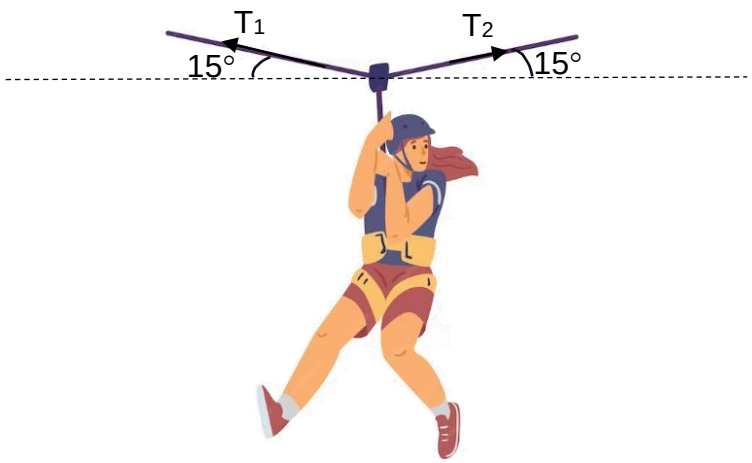

Fig. 1.1 (not to scale)

Two contact forces, tensions, T_1 and T_2 are acting on the rope as shown.
To keep stationary, a third, non-contact force is acting on this CHRian by the *gravitational field* of the earth.

(a) State what is meant by the *gravitational field*.

……..

……..[1]

(b) Given that T_1 and T_2 are each 850 N and tilted at an angle of 15° from the horizontal, Use a vector diagram, determine the resultant force from these two tensions.
State clearly the scale used.

scale:……[1]

resultant force =……[2]

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(c) Explain, by applying Newton's Law, how the answer to **(b)** can be used to determine the magnitude and direction of the non-contact force.

……..

……..

……..

……..[2]

[Total: 6]

2 Fig. 2.1 shows a wind turbine used to generate electricity.

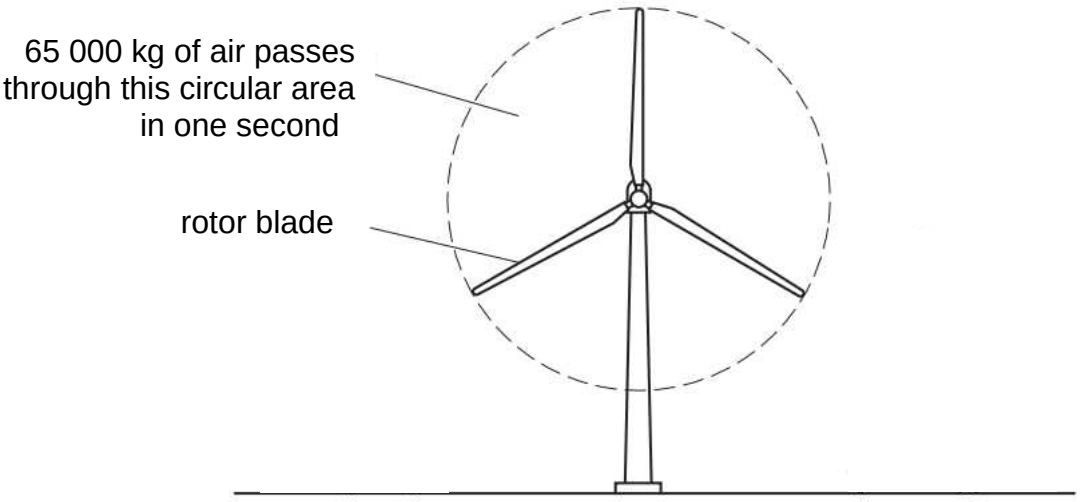

Fig. 2.1

(a) The wind blows directly towards the turbine with a speed of 12 m/s.
In one second, 65 000 kg of air passes through the circular area swept out by the rotor blades.

Calculate the energy in the kinetic store of this mass of air in one second.

energy in the kinetic store = ……[2]

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(b) Given that the efficiency of this wind turbine is 72%.

Calculate the amount of electrical power generated.

electrical power = ……..[1]

(c) Using the principle of conservation of energy and energy stores, describe how energy transfer takes place in the wind turbine.

……..

……..

……..

……[2]

(d) The potential difference between the electrical turbine is 3.5 MV.

Calculate the electric current produced.

current = ……..[2]

[Total: 7]

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3 Fig. 3.1 shows a toy water rocket.

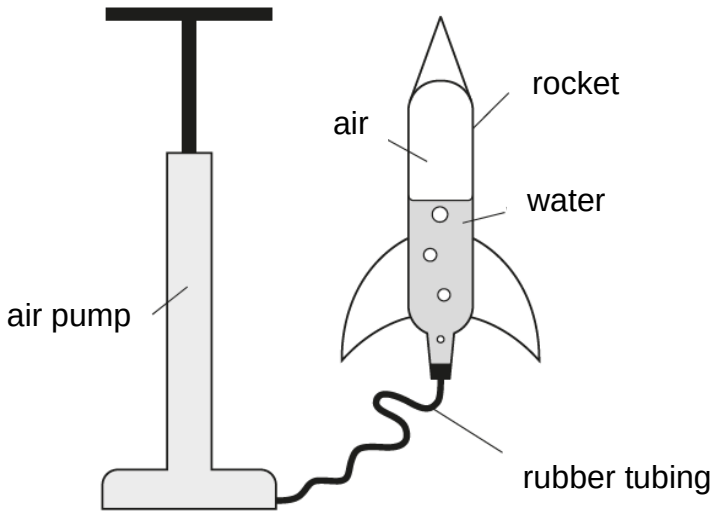

Fig. 3.1

The rocket is half-filled with water and connected by rubber tubing to a pump.
Air is then pumped into the rocket so that the pressure in the rocket increases.

(a) Explain, using ideas about molecules, why pumping air in the rocket increases the pressure in the rocket.

……..

……..

……..

……..[2]

(b) State and explain, using ideas about molecules, how the pressure of the air in the rocket would change when the temperature of the air in the rocket is increased.

……..

……..

……..

……..[2]

[Total:4]

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4 Fig. 4.1 shows a tank with a base area of 5.0 m^2 connected at the bottom via a horizontal pipe to a vertical tube of cross-sectional area 0.10 m^2.
Both the tank and the vertical tube are exposed to the atmosphere.

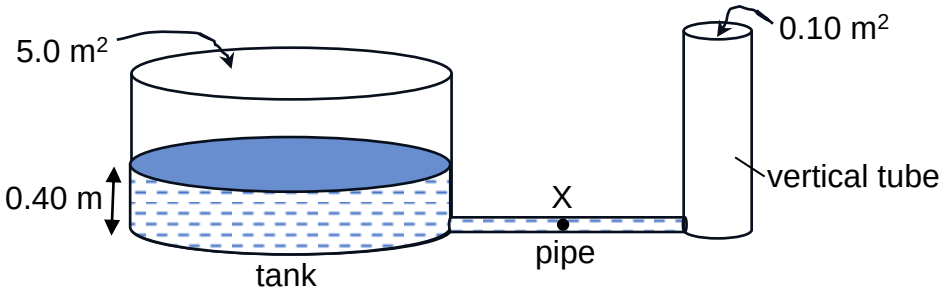

Fig. 4.1 (not draw to scale)

A liquid of density 900 kg/m^3 is poured into the tank to a depth of 0.40 m.

(a) On Fig. 4.1, clearly show the depth of liquid in the vertical tube. [1]

(b) Calculate the mass of liquid in the tank only. (You may ignore the volume of pipe).

mass of liquid in the tank = …….[2]

(c) Calculate the total pressure at point X indicated on Fig. 4.1.
Given that the atmospheric pressure is 100 kPa. Take g = 10 N/kg.

total pressure = …….[3]

[Total: 6]

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5 Fig. 5.1 shows a geothermal reservoir.

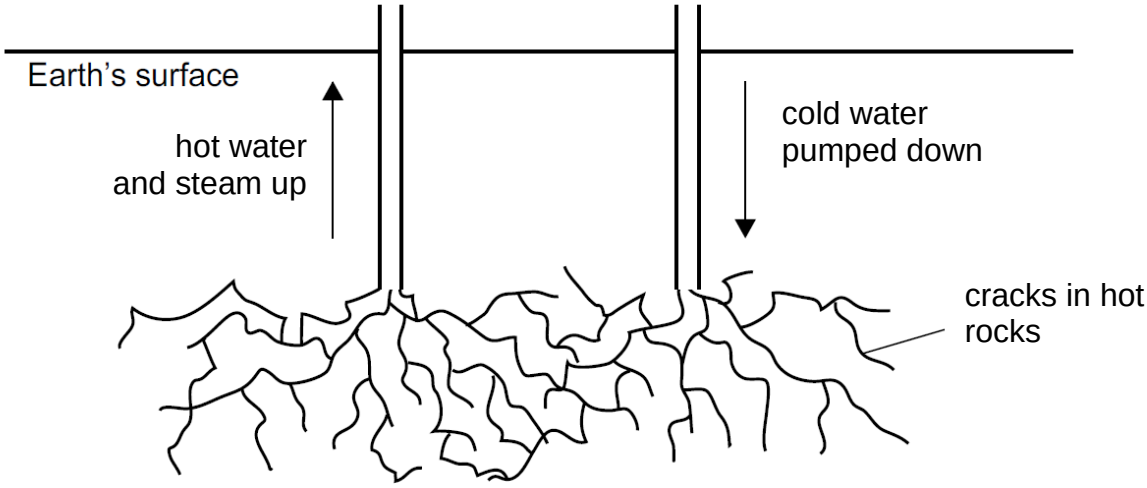

Fig. 5.1

(a) 1500 kg of cold water at a temperature of 25 °C is pumped down to the hot rocks. The water rises back up as 50% hot water and 50% steam.

Both the steam and the hot water are both at a temperature of 100 °C.
The specific heat capacity of water is 4200 J / (kg °C) and the latent heat of vaporisation of water is 2260 kJ/kg.

Calculate the total energy required to turn 1500 kg of water from 25 °C to 50% water and 50% steam at 100°C.

total energy = …….. [3]

(b) Explain why the pipe carrying the cold water is usually made of metal and painted black.

……

……

……

……[2]

[Total: 5]

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6 Echolocation is used in nature by some animals to locate distant objects (such as a prey) by means of high-pitched sound waves.

Fig 6.1 shows a bat flying at a speed of 6.0 m/s towards a stationary moth.

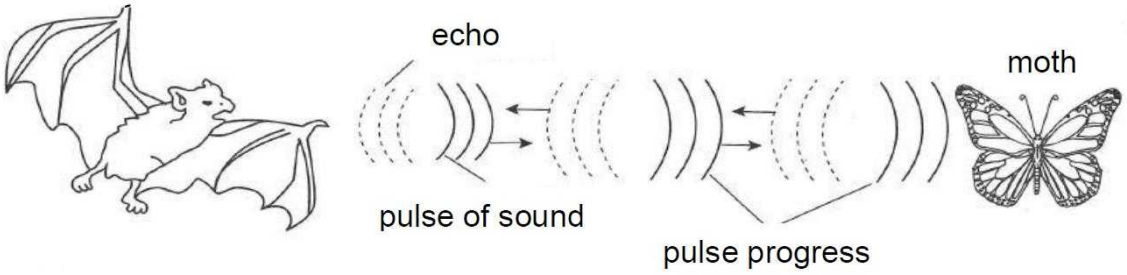

Fig. 6.1 (not to scale)

(a) Describe how sound waves produced by the bat travel through the air, reached the moth and eventually return to the bat.

……..

……..

……..

……[2]

(b) Fig. 6.2 shows the initial position of the bat at A. After sending a high-pitched sound wave, it flew for 0.50 s. The echo is received by the bat at position B.

Fig. 6.2

Given that the speed of sound in air is 330 m/s, calculate the initial distance between the bat and the stationary moth.

Show your working clearly.

distance = ……[2]

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(c) Radar, a system similar to echolocation, is used for communication purposes.

Radar makes use of radio waves that are transmitted and the reflected radio waves are detected by sensors.

(i) State **two** differences between radio waves and sound waves.

……..……..……..

……..……

……..……..……..

……..……...[2]

(ii) A radar signal of frequency 1.5 GHz is sent to long range air traffic communication.

Calculate the wavelength of this radar.
State clearly any constant used.

wavelength = ……..[2]

[Total: 8]

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7 Fig. 7.1 shows two parallel rays of light, one red and one blue, entering a glass prism. The blue ray is also shown incident on a different side of the prism after passing through the prism.

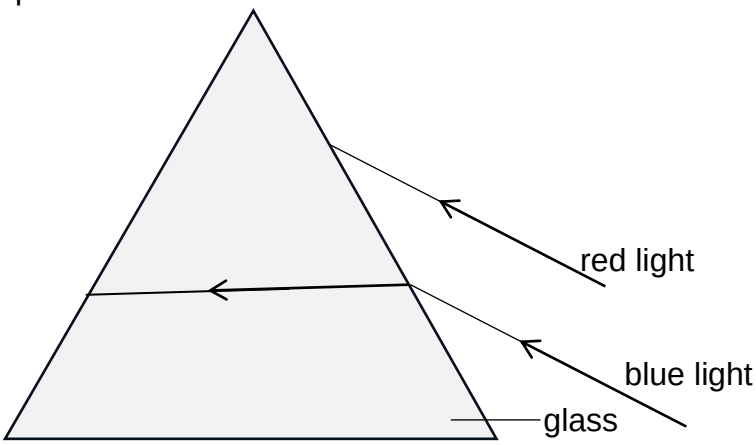

Fig. 7.1 (not to scale)

The ray of blue light strikes the left side of the prism at an angle equal to its critical angle c which is equal to 42°.

(a) On Fig. 7.1, draw and label the incident and refracted angles for the blue light ray. [1]

(b) With reference to the blue light ray, state what is meant by critical angle.
You may draw on Fig. 7.1 to support your answer.

……..

……..

……[2]

(c) Calculate the refractive index for the blue light.

refractive index = ……[2]

(d) The refractive index of glass for red light is smaller than the refractive index for blue light.

On Fig. 7.1, draw the path of the red light as it travels in the prism and after it strikes the left side of the prism. [2]

[Total:7]

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8 Fig. 8.1 shows a circuit consisting of a 9.0 V cell, two resistors R_1 and R_2 of 120 Ω each, a light dependent resistor (LDR), and a thermistor.

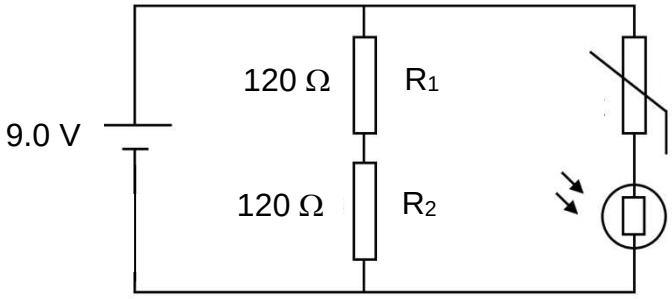

Fig. 8.1

Table 8.2 shows the range of resistance values for the LDR and the thermistor. The resistance of the thermistor varies linearly with temperature.

device	temperature /°C	light intensity	resistance /Ω
thermistor	20		200
	35		50
LDR		bright noon day	100
		night	200

Table 8.2

(a) Calculate the effective resistance of this circuit when it is during the night with a temperature of 20 °C.

effective resistance = ……[2]

(b) The output voltage V_{out} across the LDR is connected to a fan that will be switched on when the output voltage Vout ≥ 6.0 V.

Using Table 8.2, state under what conditions (temperature and light intensity) will the fan be switched on. Show your working on the space given below.

……..

……[2]

[Total:4]

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9 Fig. 9.1 shows a simple d.c. motor used in a toy car.

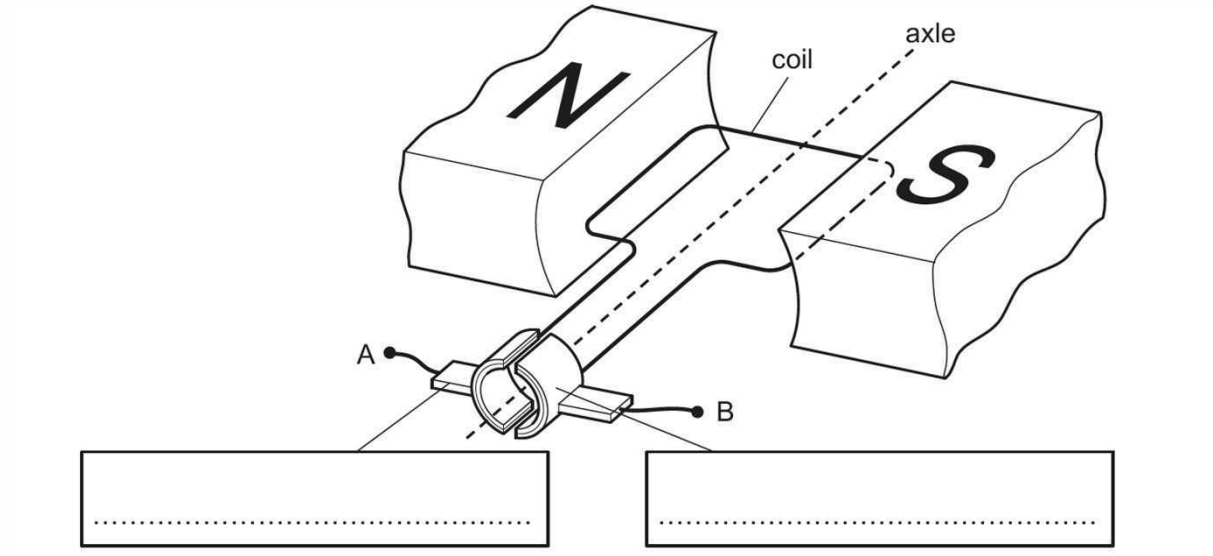

Fig. 9.1

Terminals A and B are connected to a battery and the motor rotates.

(a) On Fig. 9.1, name to parts of the motor inside the boxes provided. [2]

(b) State the effect of switching the positions of the North and South poles and increasing the number of turns of the coil.

……..

……..

……..

……[2]

(c) The power supply to the motor is switched on and off at a steady rate.

Fig. 9.2 shows how the speed of the toy car varies with time as a result of the power supply being switched on and off.

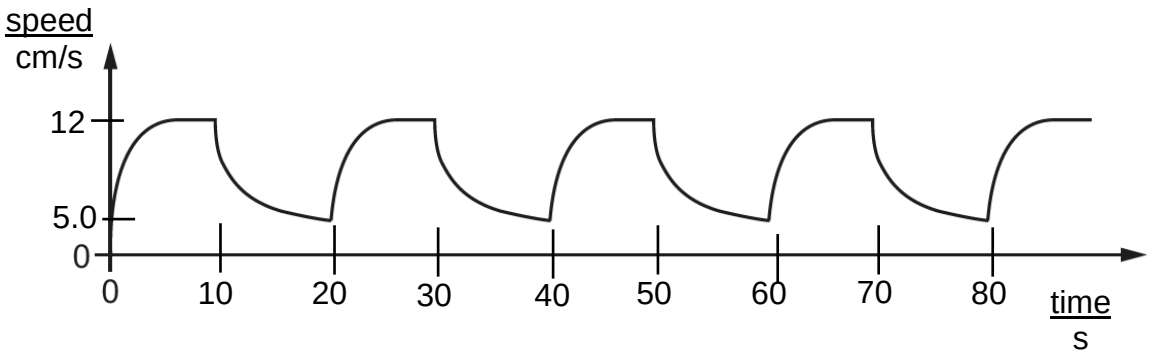

Fig. 9.2

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Describe the motion of the toy car.

……

……

……

……[2]

[Total:6]

10 A radioactive isotope, Uranium emits alpha (α)-particles and gamma (γ) rays.

(a) A uranium $^{238}_{92}U$ atom emits an α-particle and γ rays to form Thorium, *Th*.

Write a nuclide equation to represent this decay.

……[1]

(b) Describe how you verify that only α-particles and γ rays are emitted. Use the space provided to describe your answer.

……

……

……

……

……

……

……

……

……

……

[3]

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(c) An experiment was conducted to find the range of α-particles in air.
Table 10.1 shows the results of the experiment.

distance from the source to the detector / cm	count rate / counts per minute
1.0	731
2.0	688
3.0	604
4.0	545
5.0	24
6.0	26
7.0	25
8.0	24
9.0	26

Table 10.1

(i) Estimate the background radiation count rate.

……[1]

(ii) Based on your answer in **(i)**, estimate the count rate of the radioactive source when the source is at a distance of 3.0 cm from the detector.

count rate = ……[1]

(iii) State and explain the maximum distance that α-particles can travel from the source.

……

……

……[1]

(d) Thorium, *Th* is an isotope which further emits β-particles and γ-rays to become Protactinium, *Pa.*

(i) Define the term isotope.

……

……[1]

(ii) Write a nuclei equation and state the atomic number of protactinium.

……

……[1]

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(iii) Fig. 10.2 shows the percentage activtiy decay curve of a sample of the unstable thorium nuclei *isotope* that decays per second.

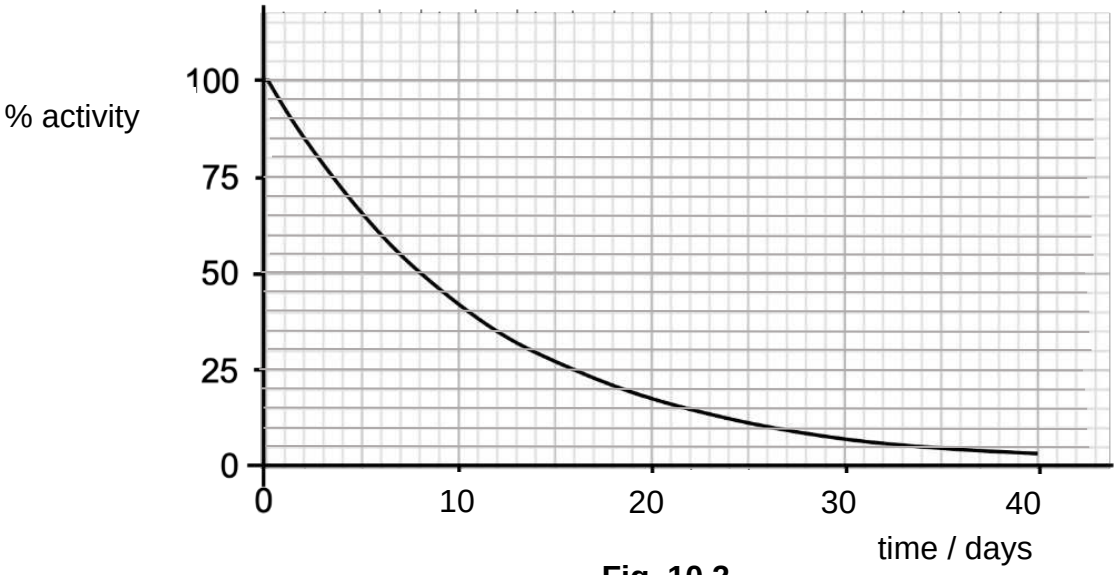

Fig. 10.2

Using Fig. 10.2, determine the half-life of this thorium isotope.
Show your working clearly.

half-life of Th isotope = ……[2]

(e) State an application of radioactivity in the medical or industrial uses.

…..……

……[1]

[Total:12]

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11 Fig. 11.1 shows an electrostatic precipitator with the key components.

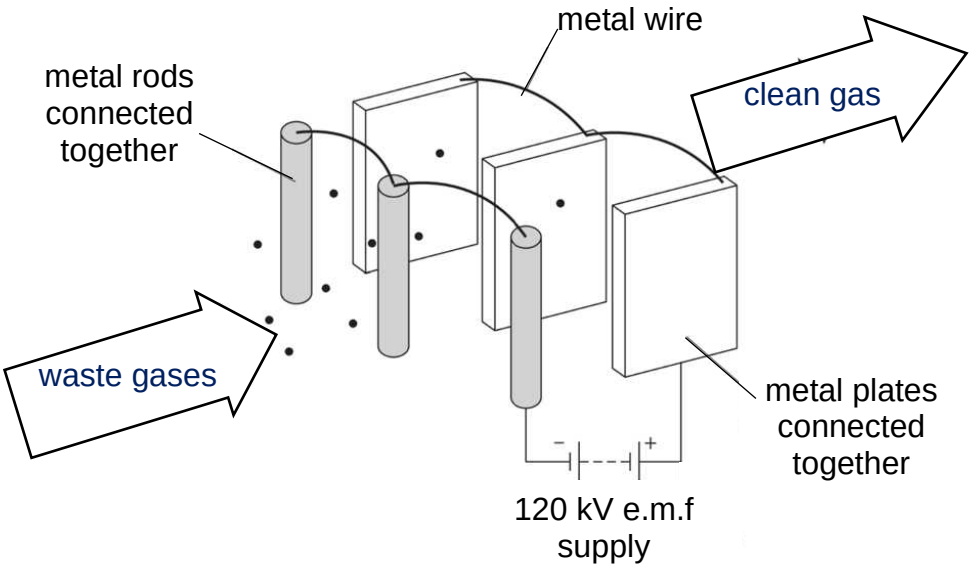

Fig. 11.1

(a) Using the law of electrostatic, explain how the waste gases (initially uncharged) passing through the metal rods get charged and eventually are removed, leaving the metal plates as clean gas.

……..

……..

……..

……..

……..

……[2]

(b) Fig. 11.2 shows a single isolated negatively charged particle.
On Fig. 11.2, draw the electric field on this negatively charge particle.

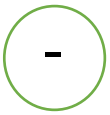

Fig 11.2

[1]

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(c) The discharge current from the 120 kV e.m.f. supply is 1.5 mA in 2.0 s.

Calculate the amount of energy of this discharge.

energy = ……[2]

[Total: 5]

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Section B

Answer **one** question from this section.

12 (a) A simple iron-cored transformer has an input voltage of 120 turns and is connected to an alternating current power supply of 25 V.

Describe the set-up of this transformer that can be used to step up the voltage to 200 V. In your account, you should:

- include a diagram to show the structure of this transformer
- state the key information essential for this step-up transformer to work
- state any assumption(s) made.

……

……

……

……[4]

(b) Fig. 12.1 shows a solenoid is held in a vertical position. The solenoid is connected to a sensitive, centre-zero galvanometer. A vertical bar magnet is held stationary at position X just above the solenoid.

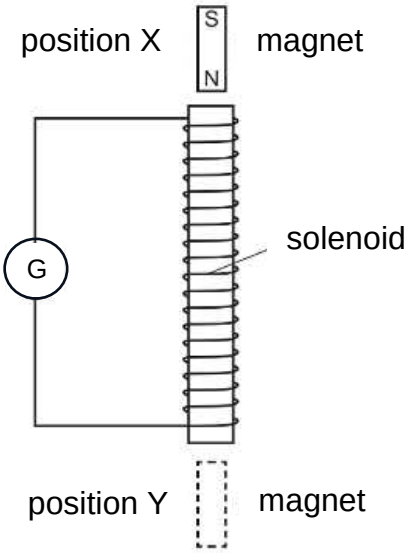

Fig. 12.1

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The magnet is released and it drops through the solenoid.

During the initial stage of the drop, the sensitive galvanometer shows a small deflection to the left.

Explain why the galvanometer shows a deflection.

……..

……..

……..

……..

……[2]

(c) The magnet passes the middle point of the solenoid and continues to drop.

It reaches position Y as shown in Fig. 12.1.

Describe and explain what is observed on the galvanometer as the magnet falls from the middle point of the solenoid to position Y.

……..

……..

……..

……..

……[2]

(d) Fig. 12.2 shows the voltage output against time from a simple alternating current generator.

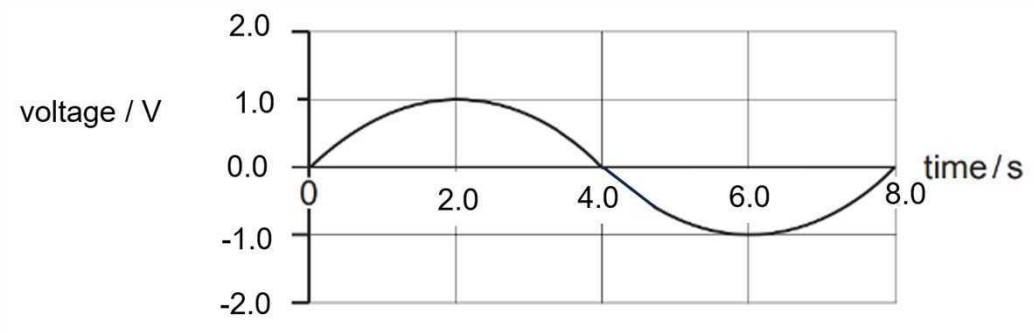

Fig. 12.2

On Fig. 12.2, draw the voltage output against time if the generator rotates at twice the original speed. [2]

[Total: 10]

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13 Fig. 13.1 shows an electric oven with two heating elements arranged at the top and bottom to provide a uniform heating to food placed in the oven.

A 230 V alternating current (a.c.) power supply is used as a source.

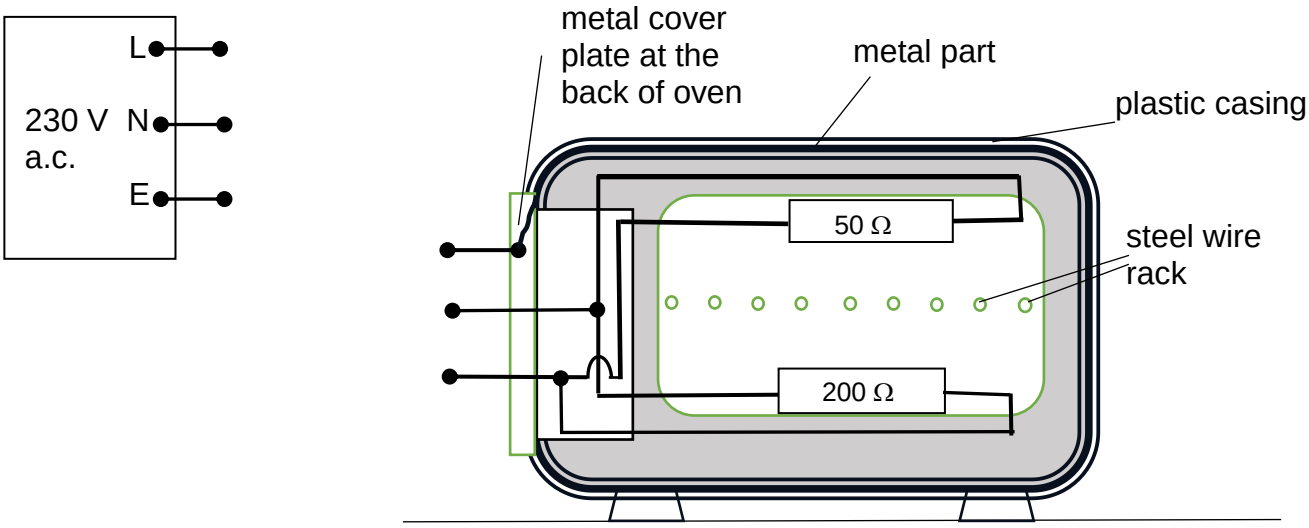

Fig. 13.1

(a) On Fig. 13.1, draw lines to complete the circuit diagram to show how the live, neutral and earth wires should be connected to the 230 V a.c. supply.

Include a fuse and a switch in your circuit diagram. [2]

(b) Determine the current based on the arrangement of the heating elements when connected to the a.c. supply and switched on.

current = ……[2]

(c) Suggest a suitable fuse rating given the choice of 3 A, 5 A, 7A, 9 A and 13 A. Explain your answer how you arrive at your choice.

……..

……..

……[1]

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(d) A restaurant uses five electric ovens daily for 3.0 hours.

Table 13.2 shows the cost of electricity supplied by two energy retailers.

energy retailer	monthly price plan	
	type	electricity rate
X	fixed price	30 cents/kWh
Y	fixed price with rebate	32 cents/kwh ($15 rebate for consumption more than 500 kWh)

Table 13.2

Based on Table 13.2, explain which energy retailer would be more provide lesser cost. Show your working clearly on the space given below.

energy retailer …… would provide a lesser cost [3]

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(e) Fig. 13.3 shows the same electric oven with the heating elements only.

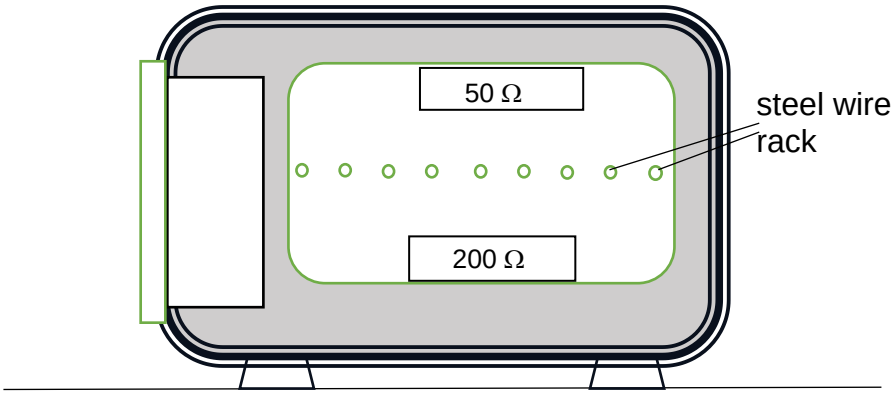

Fig. 13.3

Explain how this arrangement of the heating elements increase the temperature of the air in the oven to allow the food to be eventually uniformly cooked.

You may draw on Fig. 13.3 to explain.

……..

……..

……..

……..

……..

……[2]

[Total: 10]

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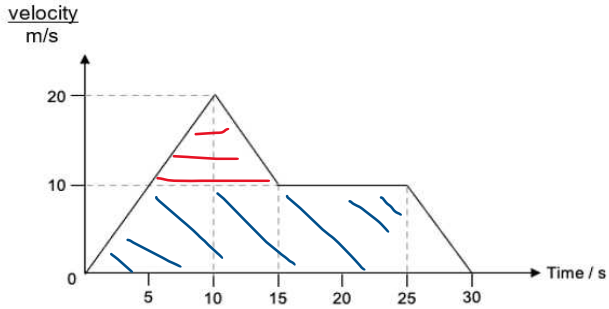
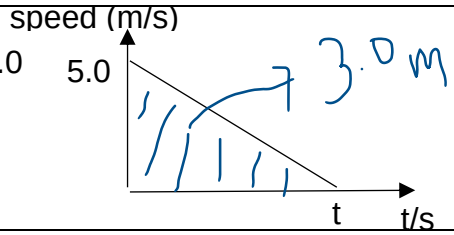
CHR SEC 4 EXP SCIENCE PHYSICS (5086) PRELIM 2024
PROPOSED MARKING SCHEME (FOR TEACHERS ONLY)

Paper 1:

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

Q	Suggested Answer-Concept-Explanation (ACE approach)	Marks
1	**Answer (A):** A **Concept (C):** Range and precision of instrument **Explanation (E):** Internal diameter of test-tube -digital calipers Thickness of wire – digital micrometer screw gauge	[1]
2	**A:** C **C:** Common examples of scalar and vector quantities **E:** Four vector quantities: i. force, ii. displacement, iii. acceleration, iv. change of velocity	[1]
3	**A:** B Distance travelled = area under speed-time graph [C] = [½ (25 + 20) (10)] + ½ (10) (10) [E] = 275 m [A]  Average speed = total distance travelled / total time taken [C] = 275 / 25 [E] = 11 m/s [A]	[1]
4	**A:** B **C:** Area under speed-time graph =3.0 ½ (5) (t) = 3.0 [E] ∴t = 1.2 s [A]  	[1]

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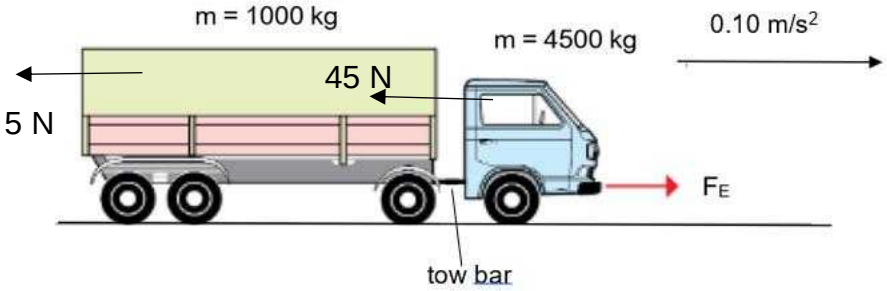
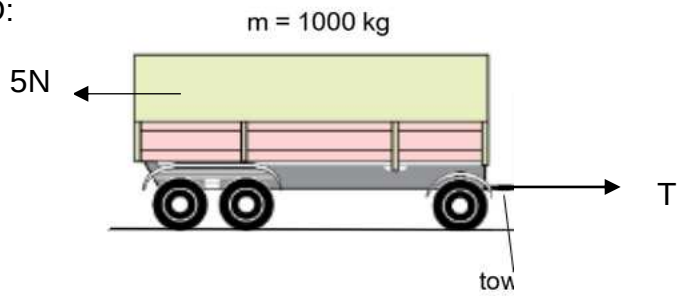
5	**A:** A **C:** Acceleration of free-fall near earth surface, disregard air resistance **E:** Constant acceleration	[1]
6	**A:** C **C:** inertia **E:** mass is the property that resists change in motion of the body	[1]
7	**A:** D **C: Resultant force F = ma** F_E - 45 - 5 = (4500 + 1000) (0.10) [E] F_E = 600 N  FBD:  Resultant force F = ma [C] T -5 = 1000 (0.1) [E] ∴ T = 105 N Use FBD on the engine to check.	[1]
8	**A**: C **Using Principle of Moments, taking moments about P,** Sum of CWM = Sum of ACWM [C] F x 0.75 = W x 0.25 [E] W = 3F ∴ F = 1/3 W Total upward force = Total downward force [C] F + P = W P = W – F = W - 1/3 W = 2/3 W Alternatively, take moments about 100 cm mark to arrive at P = 2/3 W	[1]
9	**A:** B; Object with broadest base, lowest CG [E] gives the greatest stability [C]	[1]

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<table>
<tr><td>10</td><td>A: D
Adding weights lower the CG [E] such that the CG is below the pivot for stability. [C]</td><td>[1]</td></tr>
<tr><td>11</td><td>A: D
For hydraulic press system, pressure is transmitted from piston X to piston Y. $P_x = P_Y$; $\frac{F_x}{A_x} = \frac{F_Y}{A_Y}$; $F_Y = F_x \frac{A_y}{A_x}$ [C]
E: reducing diameter of X and increasing the diameter of Y will increase the force to life the load at Y.</td><td>[1]</td></tr>
<tr><td>12</td><td>A: B
As the box moves up the rough slope, there would be some energy is transferred in the form of heat to the surrounding. [E]
C: Principle of conservation of energy.</td><td>[1]</td></tr>
<tr><td>13</td><td>A: B
During boiling, the temperature of the liquid remains constant. [C] Thus the average speed of the particles remain constant and the internal kinetic energy of the particles will also remain constant. [E]. The energy taken in will be used to overcome the intermolecular forces of attraction between the particles. [A] Internal potential energy will increase.</td><td>[1]</td></tr>
<tr><td>14</td><td>A: A
Heat conduction [C] rate: [E]
<table>
<tr><td>aluminium</td><td>L</td><td>12 s to rise by 2°C</td><td>✓</td></tr>
<tr><td>Copper</td><td>L</td><td>6 s to rise by 2°C</td><td></td></tr>
<tr><td>Fibreglass</td><td>L</td><td>77 s to rise by 2°C</td><td>✓</td></tr>
<tr><td>Polystyrene</td><td>L</td><td>30 s to rise by 2°C</td><td></td></tr>
</table></td><td></td></tr>
<tr><td>15</td><td>A: C
E = mc∆T [C]
c = $\frac{E}{m\Delta T}$ [E]</td><td></td></tr>
<tr><td>16</td><td>A: C
C: Electrical energy supplied = Heat gain during boiling
E: $Pt = mL_v$
1500 x (700 -100) = 0.550 x L_v
∴ L_v = 1600 kJ/kg</td><td></td></tr>
<tr><td>17</td><td>A: D
• Frequency of the waves remain the same as it is dependent on the dipper (source). [C]
• Speed of waves, v = fλ [C]
= 2.5 x (3.0 cm) [E]
= 7.5 cm/s [A]
• This wave is ta transverse wave [C]
• Wavefronts [C] are farther apart in the deep region and closer together in the shallow region as observed from the wavelengths.</td><td></td></tr>
</table>

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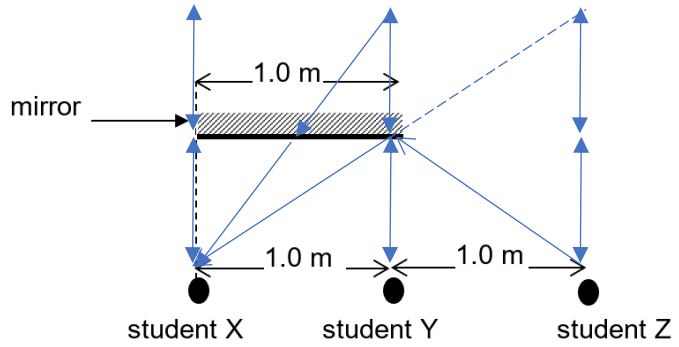
18	**A:** C Wavelength = 2.0 m (from displacement-distance graph) [E] Amplitude = 0.50 m (from both graphs) [C] Frequency = 1/T [C] = 1/ 4.0 = 0.25 Hz (from displacement-time graph) Speed = $f\lambda$ [C] = (0.25 x 2.0) = 0.50 m/s	[1]
19	**A:** D High frequency electromagnetic waves such as X-rays and γ-rays can cause ionising effects on living cells. [E] (not heating effects). Infra-red and especially ultraviolet rays result in heating effect; skin cancer. Over-exposure to radio waves does not cause skin cancer.	[1]
20	**A:** B Only student X can see the images of the other two students as shown. Student Y can only see image of student X but not student Z. Student Z can only see image of student X but not student Y.  Object distance is same as image distance for plane mirror. [C]	[1]
21	**A:** B Image is real, inverted and magnified. Magnification is 2.0 When object is placed less than focal length, image is upright and magnified. [C] When object is placed at twice focal length, image is same size. [C]	[1]
22	**A:** A Electrical field pattern between a positive and a negative point charges. [C]	[1]
23	**A:** D A, B and C are examples of potential hazard in electrostatic charging. D is a useful application of electrostatic. [E]	[1]
24	**A: C** Q = It [C] 35 = I x 1.0 x 10^{-3} [E] ∴ I = 35 000 A or 35 kA [A]	[1]
25	**A:** B; Concept R = $\rho L/A$	[1]

R	L	D
4R	L	D/2
2R	L/2	D/2
R/4	L	2D

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<table>
<tr><td>26</td><td>

A: C
C: Effective resistance in series, parallel and combinations
E:

Effective resistance	P	Q	R	S
	150 Ω	300 Ω	33 Ω	67 Ω

∴ RSPQ from smallest to highest [A]

</td><td>[1]</td></tr>
<tr><td>27</td><td>

A: D
C: action of a variable potential divider (potentiometer)
E: A short circuit occurs at 500 Ω resistor. Therefore p.d. across 5.0 kΩ is 5.00 V

</td><td>[1]</td></tr>
<tr><td>28</td><td>

A: B
C: the effect of temperature increase on the resistance of a metallic conductor and filament lamp
E: As temperature increases, there is increase in vibration of the metallic atoms in their fixed positions. This increases the number of collisions between the free electrons and the metallic atoms, which in turn opposes or slows down the flow of free electrons. Therefore resistance increases and current flow decreases over time.

</td><td>[1]</td></tr>
<tr><td>29</td><td>

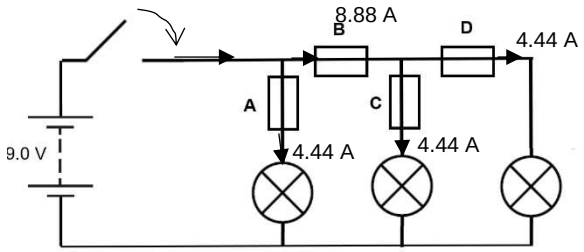
A: B
E:
✓ The annual unit cost of electricity = $542/1650 = $0.328
✓ Total energy consumption per year = 1650 000 x 60 s x 60 min
= 5.94 GJ
✓ When operating for 4.0 min, energy consumed E = VIt [C]
= 2800 x 4.0 x 60s
= 672 kJ
× Operating current I = P/V [C]
= 2800 / 230
= 12. 2 A

</td><td>[1]</td></tr>
<tr><td>30</td><td>

A: D
C: meaning of the terms live (brown), neutral (blue) and earth (green/yellow) [E]

</td><td>[1]</td></tr>
<tr><td>31</td><td>

A: B
C: P = IV [C]
40 = I (9.0) [E]
I = 4.44 A



</td><td>[1]</td></tr>
<tr><td>32</td><td>

A: B
C: Soft iron is used for the core of electromagnet and copper wire is used for electromagnet. [E]

</td><td>[1]</td></tr>
</table>

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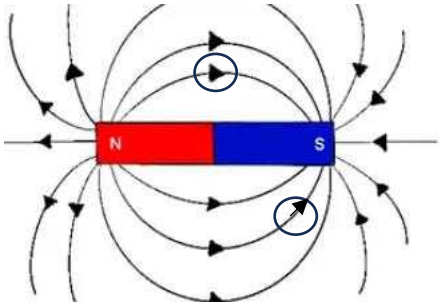
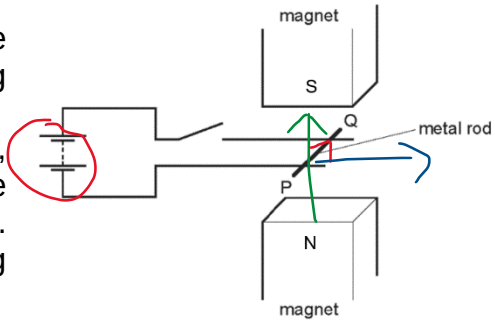
33	**A:** A **C:** The plotting compass cane be used to determine the diretion of the magnetic field as shown. [E]  	[1]
34	**A:** D **C:** Properties of magnets **E:** Based on the results recorded, the two possible conclusions can be made. With these, we can conclude only option D is wrong.	[1]
35	**A:** B When the switch is closed, the metal rod move to the left using Flemimng's left hand rule. [C] To make the rod move to the right, we can reverse the direction of the battery terminals as shown in red. The result will be the rod rolling towards the right. [A]  	
36	**A:** A **C:** Magnetic field lines round straight current-carrying conductors.	[1]

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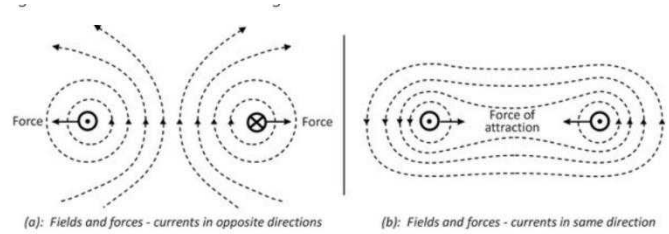
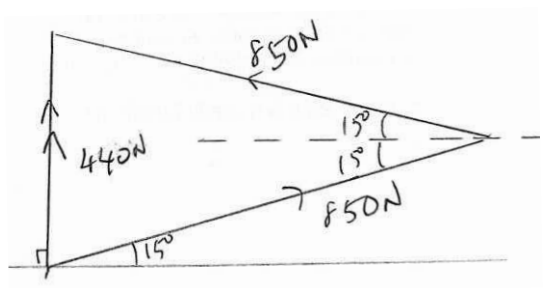
	E: If the directions of the current are in the same direction, there will be attractive force. If they are in opposite direction, there will be repusion as shown below.  (a): Fields and forces - currents in opposite directions (b): Fields and forces - currents in same direction	
37	**A:** B Only when there is a changing magnetic field in the primary coil will induce an e.m.f. [C] and hence a current in the secondary coil. [E]	[1]
38	**A:** C **C:** $\frac{V_S}{V_p} = \frac{N_S}{N_P}$ **E:** $\frac{5.0}{230} = \frac{100}{N_P}$ $\therefore N_p = 4600$	[1]
39	**A:** D Reason why high voltage – low current; less energy wasted in cables [C] Reason why using an alternating current – voltage can be stepped up or down. [E]	[1]
40	**A:** C The diagram illustrates a chain of nuclear fission [C] reactions. Particle X which is a neutron is used to bombard the uranium atom resulting in the decay into two daughter nuclei and more neutrons to further split the uranium atoms. [E]	[1]

PAPER 2: Section A

Q	Suggested Answer (ACE approach)	Remarks
1a	*Gravitational field* refers to a region in which a mass experiences a force due to gravitational attraction. [C]	[1]
Comments: Well answered by many students!! 😊		
1b	Scale: 1 cm = 10 N  	[1] [1]

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	resultant force = 440 N vertical accept : 420 N to 460 N [A]	[1]
Comments: While scale is given, some students chose very odd scale e.g. 1 cm: 170N which is strongly discouraged. Some students gave the 'seemingly' correct answer with the correct magnitude but wrong orientation. E.g. This is incorrect because:		
1c	Since the CHRian is stationary, the resultant force is zero. Applying Newton's 1st law, the body at rest will remain at rest with resultant force = 0 N. Thus the (weight) downward force is 440 N.	[1] Accept e.c.f. [1]
Comments: The better students are able to quote the correct Newton's Law. Some students are awarded marks for quoting Newton's 2nd Law for sound reasoning. 😊		

Q	Suggested Answer	Remarks
2a	Kinetic store = ½ mv^2 [C] = ½ x (65 000) x $(12)^2$ [E] = **4680 kJ** [A] 3 s.f.	[1] [1]
Comments: Well answered by almost all students except for a small handful who forget to square the value of 12 even though they quoted the formula correctly.		
2b	Efficiency = $\frac{output\ energy}{input\ energy} x100\%$ [C] 72% = electrical energy / 4680 000 kJ [E] Electrical energy = 3 369 600 J in 1s or **3 370 kW** [A] 3 s.f.	Accept e.c.f. [1]
2c	Energy in the kinetic store [C] of wind is transferred mechanically [E] to the kinetic store [C] of the rotor blades of the wind turbine. Energy is transferred **electrically (by charges moving through a potential difference in the presence of the magnets)**	[1] [1]
2d	P=IV [C] 3370 000 = I x (3.5×10^6) [E] I = 0.96 A [A]	[1] Allow e.c.f. [1]
A number of students used E=QV (V=J/C) and Q= It formula which arrive at the same answer of using P=IV directly.		

Q	Suggested Answer	Remarks
3a	When more air molecules are pumped in, there will be more air molecules per volume. [E] This will increase the number of	[1]

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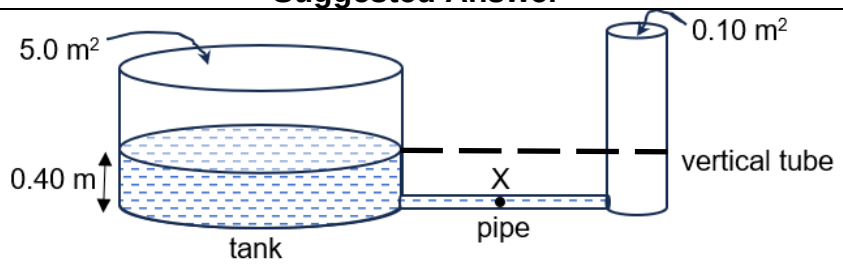
	collisions per unit time (frequency of collisions increases with the walls of the container) [E] within the same unit area. Thus pressure increases.	[1]
3b	Pressure will increase. [A] When temperature increases, the internal kinetic energy of the air increases. The average kinetic energy (or average speed) of the air molecules increases, leading to greater frequency of collisions between the air molecules and the inner walls of the rocket. [E]	[1] [1]

Q	Suggested Answer	Remarks
4a		[1]
4b	$\rho = \frac{mass}{vol}$ [C] $900 = \frac{mass}{(5.0\ x\ 0.40)}$ [E] ∴mass = 1800 kg [A]	[1] [1]
4c	Pressure = hρg [C] = (0.40) (900) (10) [E] = 3600 Pa Total pressure = 100 000 + 3 600 [E] = 103 600 Pa [A]	[1] [1] [1]

Q	Suggested Answer	Remarks
5a	Energy required to raise the temperature of 1500 kg of water from 25°C to 100 °C = mcθ = (1500) (4200) (100 -25) = 472 500 000 J Energy required to convert 50% steam = mL_v = (1500 /2) x 2260000 = 1695 000 000 J Total energy = 472 500 000 + 1695 000 000 = **2.17×10^9 J**	[1] [1] [1]
5b	Black surfaces are a good absorber of thermal energy through radiation from the ground. Also, metal is a good conductor of heat. So energy can transferred by heating via conduction.	[1] [1]
5c	Speed = distance / time [C] = (250 x 2) / (1.5) [E] = 333 m/s [A]	 [1] [1]

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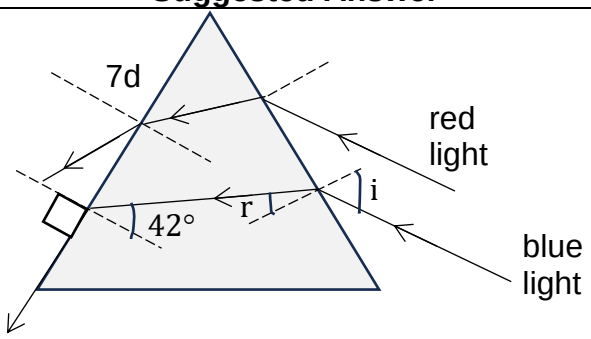
Q	Suggested Answer	Remarks
6a	Longitudinal sound waves produced by the bat cause vibrations [A] of the air molecules, coming together as high pressure regions (compressions) and pulling apart as low-pressure regions (rarefactions), parallel to the direction of wave travel. [C] The sound waves hit the moth and gets reflected back reaching the bat. [E]	[1] [1]
6b	Distance travelled by bat = speed x time [C] = 6.0 x 0.50 [E] = 3.0 m [A] Distance travelled by sound waves = speed x time [C] = 330 x 0.50 [E] = 165 m [A] Total distance = 165 + 3 = 168 ∴ d = 168 /2 [E] = 84 m [A]	[1] [1]
6ci	Any two differences • Radio waves is a transverse wave whereas sound waves is a longitudinal wave. [C] • Sound waves needs a medium to be transmitted whereas radio waves can travel through vacuum at a speed of 3.0 x 10^8 m/s [C] *Accept plausible answers	[1] [1]
6cii	v = fλ [C] 3.0 x 10^8 = 1.5 x 10^9 x λ [E] ∴λ = 0.20 m [A]	[1] [1]

Q	Suggested Answer	Remarks
7a		[1]
7b	Critical angle of 42° is the angle of incident in the optically denser medium for which the angle of refraction in the less dense medium is 90°. Mark on diagram to support the answer.	[1] [1]
7c	n = $\frac{1}{\sin c}$ [C] $n = \frac{1}{\sin 42°}$ [E] $n = 1.49$ [A]	[1]

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		[1]
7d	Refer to diagram. Bend towards normal as red light enters glass and Refract away from as red light leaves glass	 [1] [1]

Q	Suggested Answer	Remarks
8a	Effective resistance = $(\frac{1}{R_1}+\frac{1}{R_2})^{-1}$ [C] = $(\frac{1}{(120+120)}+\frac{1}{(200+200)})^{-1}$ [E] = 150 Ω [A]	[1] [1]
8b	Using the concept of potential divider, for V_{out} across the LDR ≥ 6.0 V, [C] $V_{LDR} = \frac{200}{50+200} \times 9.0\ V$ [E] = 7.2 V $V_{LDR} = \frac{100}{50+100} \times 6.0\ V$ [E] = 6.0 V From the working, it shows that the fan will be switched on when the temperature reaches 35 °C, regardless of the light intensity. [A]	[1] [1]]

Q	Suggested Answer	Remarks
9a	Carbon brushes [A] Split ring commutator [A]	[1] [1]
9b	Switching the positions of the North and South poles will result in the motor rotating in the opposite direction [E] and increasing the number of turns will cause the motor to rotate faster or at a higher frequency. [E]	[1] [1]
9c	The toy car starts with zero initial speed, increases its speed at a decreasing rate till it reaches a maximum speed of 12 m/s in 10 s. [E] It speed suddenly decreases at a decreasing rate till it reaches 5.0 m/s in another 10 s. Its speed picks up again till it reaches 12 m/s. The cycle repeats itself every 20 s. [E]	[1] [1]

Q	Suggested Answer	Remarks
10a	$^{238}_{92}U \rightarrow {}^{234}_{90}Th + {}^{4}_{2}\alpha + \gamma$ [A]	[1]
10b	• Use the Geiger-Muller (GM) counter [C]. Check the background radiation. Take note of the count rate, M_1 Expose it to the radioactive element. The count rate should increase. Place a carboard from the radioactive element, the count rate will drop, M_2. This shows that α	

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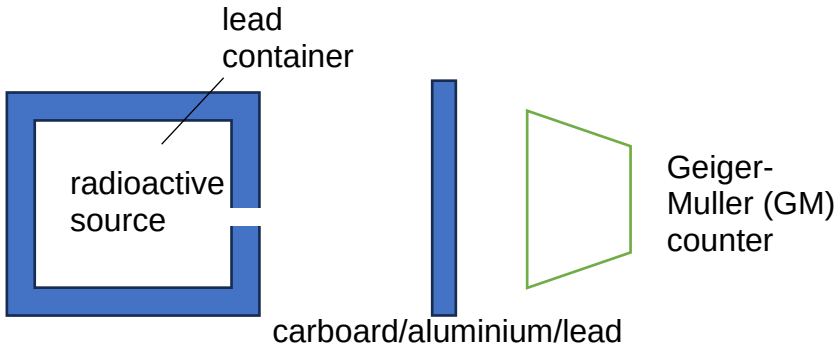
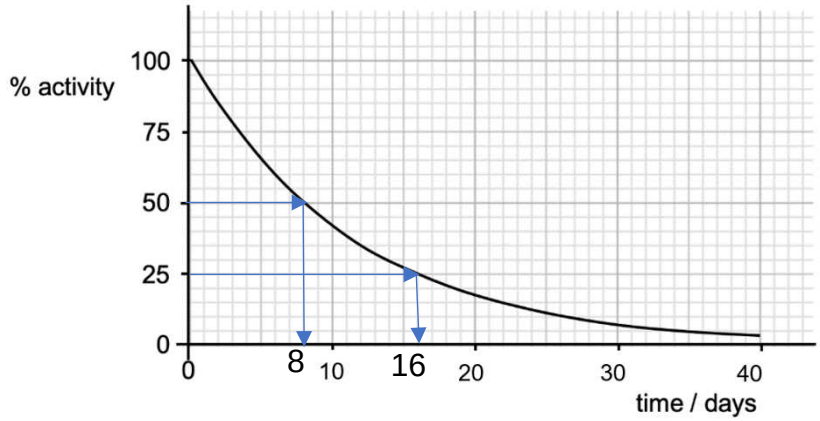
	is present. [E] • Place a few mm of aluminum, it remains at M_2. This shows that β is absent. Next, place a few cm thick of lead, the reading will drop to M_1. This shows that γ-radiation is present. [E] Diagram [A]  	[1] [1] [1]
10ci	Approximately 25 counts per minute [A]	[1]
10cii	604- 25 = 579 (allow e.c.f.)	[1]
10Ciii	Maximum distance = 4.0 cm since the count rate significantly dropped to approximately 25 counts per minute after it goes beyond 5.0 cm. [E]	[1]
10di	Isotopes are atoms of the same element that have the same number of protons but different numbers of neutrons. [C]	[1]
10dii	$^{234}_{90}Th \rightarrow {}^{234}_{91}Pa + {}^{0}_{-1}\beta + \gamma$ Atomic number of Pa is 91	[1]
10diii	 As shown, half-life of Th isotope is approximately 8 days.	[1] [1]
10e	Any one of these Radioactivity used in medical field • the detection of tumours using γ-rays • treatment of thyroid disorder • in gamma knife to destroy brain tumours	[1]

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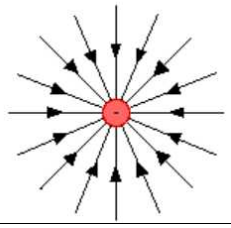
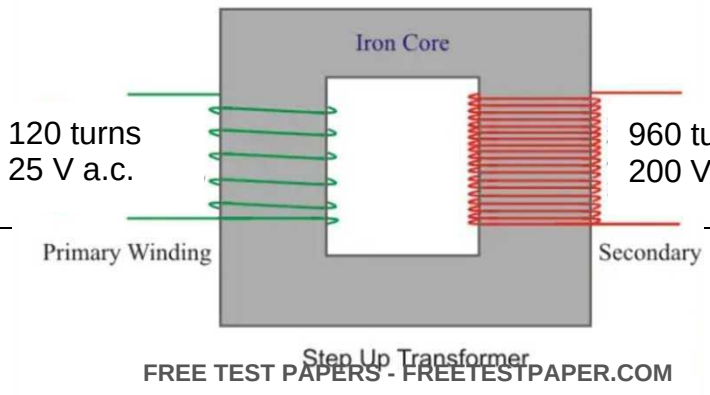
	Radioactivity used in industrial field • β-particles or γ-rays are used to measure the thickness of materials e.g. uniform thickness • α-particles used in smoke detectors	

Q	Suggested Answer	Remarks
11a	When the waste gases (initially uncharged) enters the electrostatic precipitator, they rub against the negatively charged rods, they become negatively charged as they gain electrons. [E] Charging by friction [C] As they continue to move pass the positively charged metal plates [E], they get attracted since unlike charges attracted. [C]. Unwanted particles are removed, leaving the clean gas exiting from the precipitator.	[1] [1]
11b		[1]
c	Q = It [C] = $1.5 \times 10^{-3} \times 2.0$s [E] = 3.0×10^{-3} C [A] E = QV or V = J/C [C] E = $3.0 \times 10^{-3} \times 120 \times 10^{3}$ [E] = 360 J [A] Alternatively, E = VIt [C] = $(120 \times 10^{3}) \times (1.5 \times 10^{-3}) \times (2.0)$ [E] = 360 J [A]	[1] [1]

Q	Suggested Answer	Remarks
12a	Diagram to show the step-up transformer. [A]  	[1]

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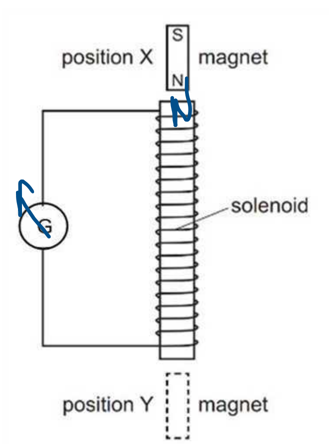
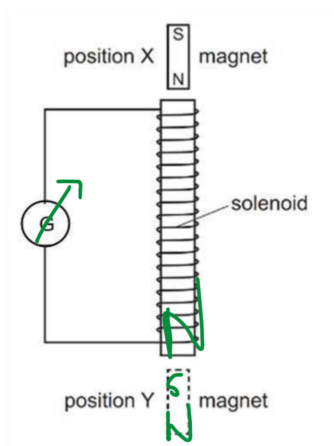
	25 a.c. supply; laminated soft-iron core [E] $\frac{N_s}{N_p} = \frac{V_s}{V_p}$, [C] $\frac{N_s}{120} = \frac{200}{25}$ [E] $N_s = 960$ [A] • Assumption: no energy losses in the system which means all the energy that is applied to the primary coil are transferred to the secondary coil. [A]	[1] [1] [1]
11b	When the magnet is dropped from the top, the magnetic field will be cut by the conducting wires in the solenoid. [E] An e.m.f. is induced according to Faraday's law of electromagnetic induction [C] and hence a current will be produced. Thus, a current deflection to the is registered to the left. [A]	[1] [1]
11c	When the magnet drop from the middle of the solenoid to the position Y, a deflection of current to the right is registered. [A]   As shown in the diagram, the lower end of the solenoid will be induced N [E] according to Lenz's law [C] and a deflection to the right will be registered.	[1] [1]

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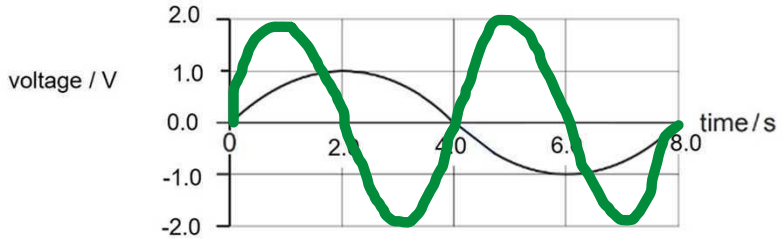
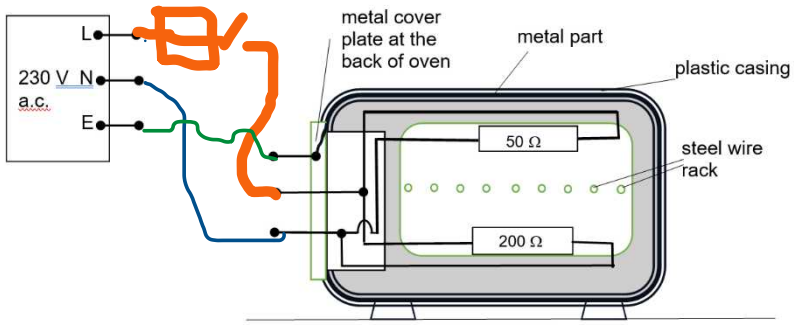
11d	 Double the frequency Double the amplitude of the e.m.f.	 [1] [1]

Q	Suggested Answer	Remarks
12a	 Correct identification of the wires Placement of fuse and switch on the live wire	 [1] [1]
13b	$\frac{1}{R_{eff}} = \frac{1}{R_1} + \frac{1}{R_2}$ $\frac{1}{R_{eff}} = \frac{1}{50} + \frac{1}{200}$ R_{eff} = 40 Ω V=RI 230 = 40 I ∴I = 5.8 A	 [1] [1]
13c	7A , slightly higher than the operating current of 5.8 A.	[1]
13d	Total energy consumption for 5 operating ovens for a month	

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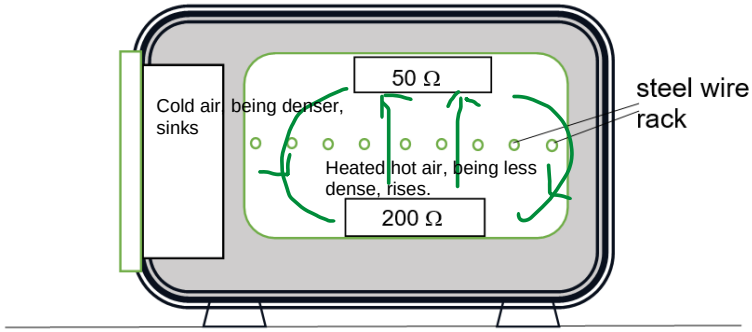
	= (230 x 5.8 /1000) kW x 3 hours x 5 ovens x 30 days = 600.3 kWh Based on energy retailer X: Cost = 600.3 kWh x $0.30 = $180.09 Based on energy retailer Y: Cost = 600.3 kWh x $0.32 = $192.096 With rebate = $192.096 - $15 = $177.096 Thus retailer Y would provide lesser cost.	[1] [1]
13e	 When the oven is heated, hot air from the base will expand and rise being less dense. [E] Cooler air will sink and in turn get heated up. This process repeats and set up the convection currents. [C] to eventually heat up the food placed on the steel wire rack. [A]	[1] [1]

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