Index Number		Name	

Anglo-Chinese School (Independent)
A Methodist Institution (Founded 1886)

PRELIMINARY EXAMINATION 2024
YEAR 4 EXPRESS

PHYSICS **6091 / 02**

Friday **2 August 2024** **1 hour 45 minutes**

READ THESE INSTRUCTIONS FIRST

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

Section A
Answer **all** questions.

Section B
Answer **only one** of the two alternative questions in this section.

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.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

Unless otherwise stated, take gravitational field strength, ***g***, to be 10 N kg^{-1}.

For Candidate's use (Section B):	
Circle the question you would like the examiner to mark for Section B. You may circle only one of the options.	
Q11 Either	Q11 Or

For Examiner's use	
Section A	
Section B	
Sig. Fig. penalty	
Unit penalty	
TOTAL	

This document consists of 21 printed pages.

Section A

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

1 A car approaches a set of traffic lights. The lights change to red at time t = 0 s.
Fig. 1.1 shows how the speed of the car changes with time. The car starts to slow down a short time after the lights change to red.

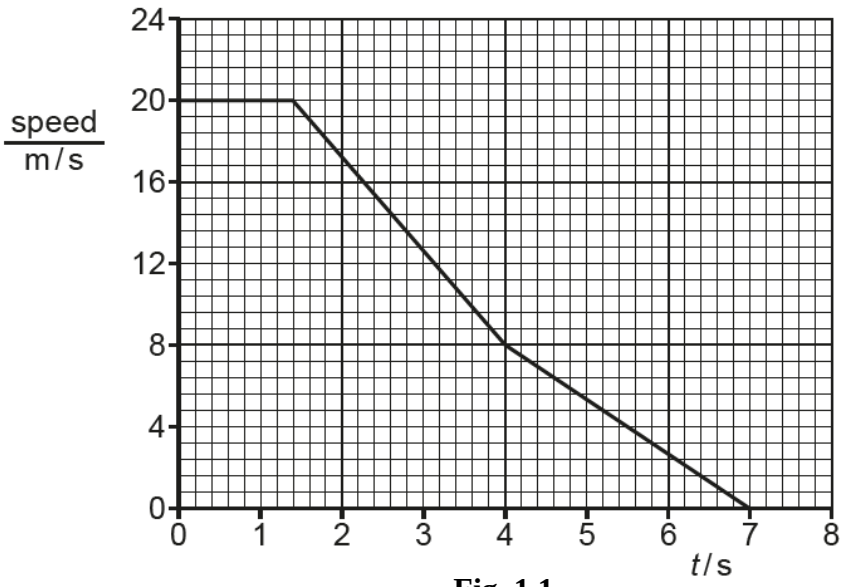


Fig. 1.1

(a) Using **Fig 1.1**,

(i) state the time between the lights changing to red and the car starting to slow down.

[1]

(ii) determine the average speed of the car from time t = 0 s to t = 4.0 s.

Average speed = _____

[2]

(b) Describe the motion of the car between time t = 4.0 s to t = 7.0 s.

[2]

2 **Fig. 2.1** shows a type of balance that is used for measuring mass. A rigid rod, of negligible mass, is pivoted about a point 6.2 cm from the centre of a pan which is attached to one end. The object being measured is placed on the centre of this pan.

A spring, attached to the rod 1.8 cm from the pivot, is attached at its other end to a fix point **P**. The force of the spring is directly proportional to its extension over the full range of operation of the balance.

A pointer, on the other side of the pivot, is set against a millimetre scale which is a distance 52.6 cm from the pivot. When the system is in equilibrium with no mass on the pan, the rod is horizontal and the pointer indicates a reading on the scale of 86 mm.

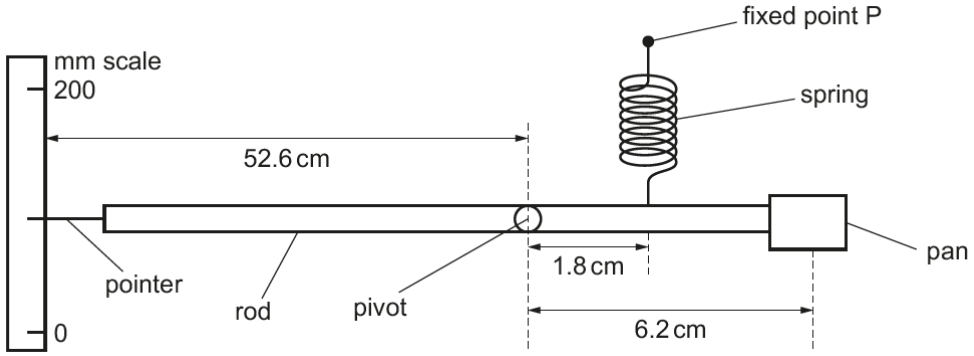


Fig. 2.1

An object of mass 0.472 kg is now placed on the pan. As a result, the pointer moves to indicate a reading of 123 mm on the scale when the system is again in equilibrium. The increase in the length of the spring is approximately 1.3 mm.

(a) State what is meant by *moment of a force*.

_____

_____

[1]

(b) Calculate the magnitude and direction of the moment of the weight of the object about the pivot.

Magnitude of Moment = _____

Direction of Moment = _____

[3]

(c) Use your answer in **(b)** to determine the increase in the tension in the spring due to the 0.472 kg mass.

ΔTension = _____

[2]

3 A cyclist travels at an initial speed of 5.0 m/s. A ball rolls in front of the bicycle at time t = 0 s. The cyclist applies a force on the brake lever. This increases the pressure in the oil by 1.2×10^6 Pa.

Fig. 3.1 shows the hydraulic braking system of the cycle. The cross-sectional area of piston **R** and piston **S** are 5.0×10^{-5} m^2 and 1.5×10^{-3} m^2 respectively.

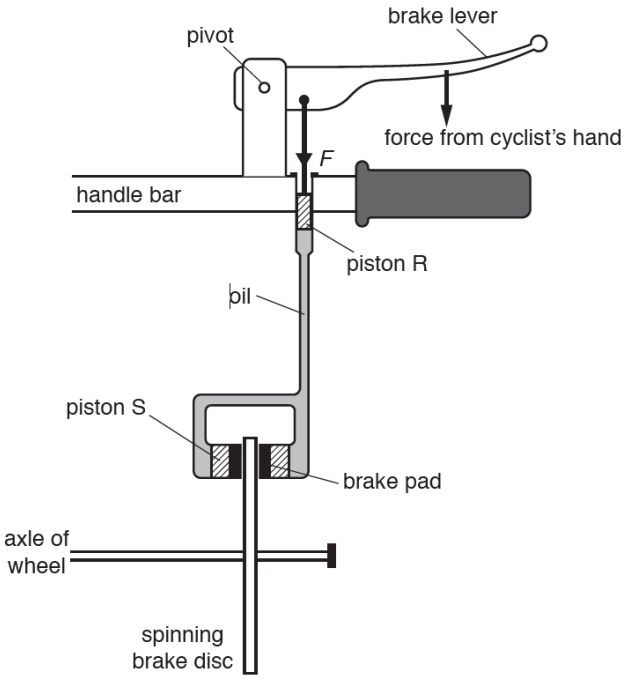


Fig. 3.1 (not drawn to scale)

(a) Refer to **Fig 3.1**,

(i) calculate the force **F** applied by the brake lever to piston **R**.

Force **F** = _____

[2]

(ii) explain why the force applied to each of the brake pads is larger than **F**.

[2]

(b) Determine the distance moved by piston **R** if each brake pad of piston **S** moves 0.20 mm.

Distance = _____

[2]

4 **Fig. 4.1** shows how the air pressure varies with time for the sound waves from two sources **A** and **B**. When the amplitude of a wave is higher, the higher chance the air particles will be compressed together in an air column, hence resulting in a higher pressure. In other words, the amplitude of a wave is directly proportional to pressure of air.

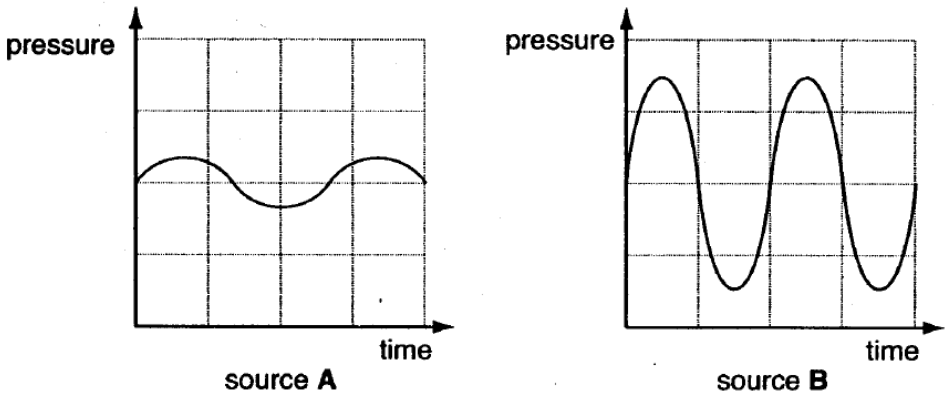


Fig. 4.1

(a) Use **Fig. 4.1** to describe and explain what differences would be heard in the sound from the two sources **A** and **B**.

[4]

(b) In a sound wave,

(i) what are the regions which are at pressures slightly below the atmospheric pressure known as?

[1]

(ii) what wave property describes the shortest distance from one compression to the next compression?

[1]

5 Visible light rays undergo refraction when passing through a converging lens made of optical glass. This property means that the image formed by the lens may have different characteristics from the object.

(a) **Fig. 5.1** shows the lens diagram of one such converging lens.

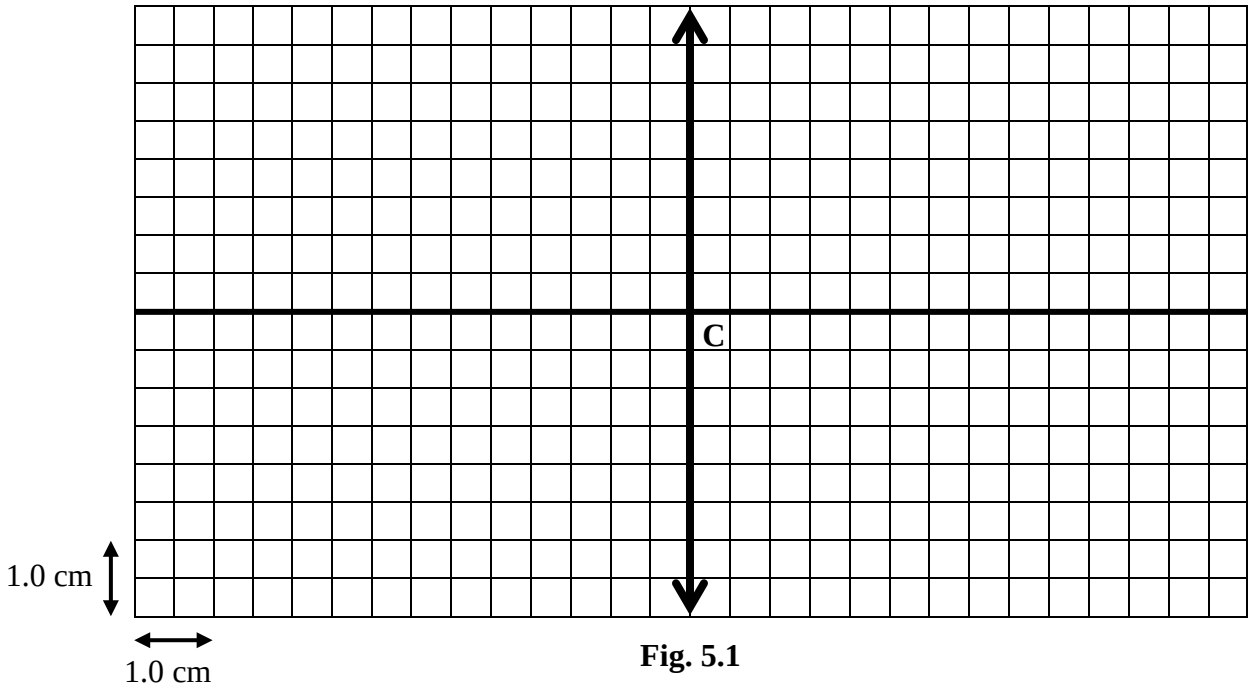


Fig. 5.1

(i) When an object of height 1.5 cm is at a distance 2.0 cm away from the optical centre **C** of the lens, a **virtual** image is formed at a distance 4.0 cm away from the optical centre **C** of the lens.

Determine, using a scaled diagram, the focal length f of the converging lens, and the height h_i of the image formed.

Draw your scaled diagram directly on the grid in **Fig. 5.1**. The scale is given on the bottom left of the grid.

f = _____

h_i = _____

[4]

(ii) Describe what will happen to the image as the object is slowly moved closer towards the lens.

_____

[1]

(b) The lens in **Fig. 5.1** is made of optical glass, and is transparent to visible light, but may not be transparent to other components of the electromagnetic wave spectrum.

To investigate this further, a selected range of wavelengths of electromagnetic waves were tested. The electromagnetic waves were directed toward the lens, and the transmittance (proportion of light that passes through the lens) was measured. The results were tabulated.

Range of tested wavelength/nm	**Transmittance / %**	**Component of electromagnetic wave spectrum**
100 - 400	0	**X**
400 - 700	95	Visible light
700 - 1200	95	**Y**

Name the components of the electromagnetic wave spectrum that **X** and **Y** correspond to.

X: _____

Y: _____

[2]

6 **Fig. 6.1** shows an electrical circuit consisting of a lamp **L**, semiconductor diode **D** and a resistor **R**.

The resistor **R** has a known value of 12.0 Ω
The current $\mathbf{I_2}$ passing through resistor **R** is 0.50 A.
The electromotive force (e.m.f.) in the circuit is 12.0 V.

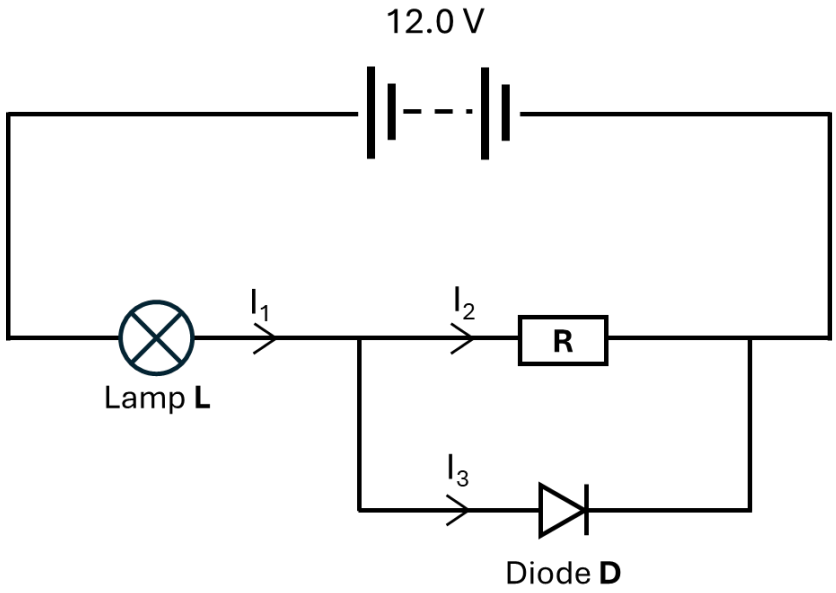


Fig. 6.1

Fig. 6.2 shows a plot of the I-V characteristics of the semiconductor diode **D** that is used in the circuit in **Fig. 6.1**.

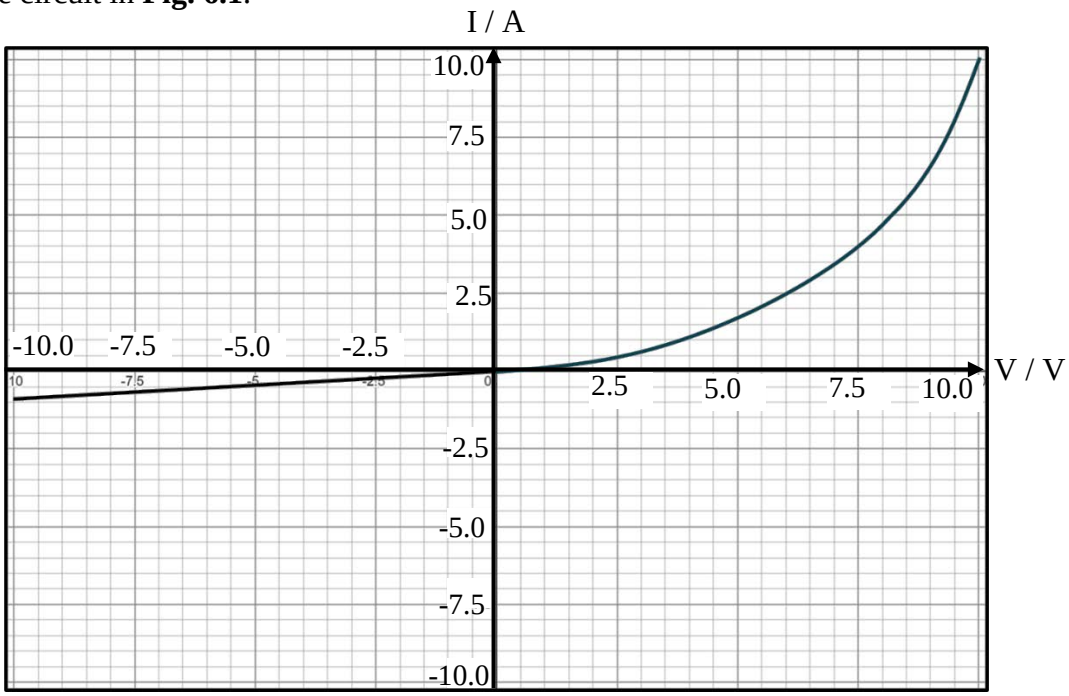


Fig. 6.2

(a) State what is meant by *electromotive force*.

_____

_____

[1]

(b) With reference to **Fig. 6.1**, calculate the potential difference (p.d.) across resistor **R**.

p.d. across **R** = _____

[2]

(c) With reference to **Fig. 6.1** and **Fig. 6.2**,

(i) determine the current $\mathbf{I_3}$ flowing through semiconductor diode **D**.

$\mathbf{I_3}$ = _____

[1]

(ii) calculate the current $\mathbf{I_1}$ flowing in the circuit.

$\mathbf{I_1}$ = _____

[1]

(iii) hence or otherwise,
determine the resistance of lightbulb **L**.

Resistance of **L** = _____
[2]

(d) Predict the effect on lightbulb **L** when the polarity of the dry cell in **Fig. 6.1** is reversed.

_____
[1]

7 An electrical appliance is rated 240 V, 840 W.

(a) The appliance is fitted with a fuse for safety.

(i) Calculate the current that flows in the appliance when it is in operation.

Current = _____
[2]

(ii) Hence, suggest a suitable fuse rating for the lamp.

Fuse rating = _____
[1]

(b) It was noted at some point that the electric lamp's metal casing was live, but the electrical lamp continued to function normally (no change in brightness) otherwise. Upon investigation, it was found that the noted effects were due to two specific electrical faults.

Indicate with a tick (✓) in the table below, which were the two electrical faults that resulted in the observed effects. [2]

Electrical Fault	Tick
The live wire was in contact the neutral wire	
The live wire was in contact with the ground wire	
The neutral wire was in contact with the metal casing	
The neutral wire was in contact with the ground wire	
The ground wire was disconnected from the ground	

8 Americium-241 is used in some smoke detectors as a radioactive source.
It undergoes nuclear decay to form an isotope of Neptunium, emitting an alpha-particle.

(a) The incomplete nuclide equation for the alpha emission is shown below:

$$^{241}_{95}Am \rightarrow \ ^{\quad}_{\quad}Np + ^{4}_{2}He$$

Complete the nuclide equation above by filling in the blanks. [1]

(b) **(i)** Describe briefly how a smoke detector works.

[2]

(ii) State one characteristic of alpha emission that makes it the ideal emission for use in smoke detectors.

[1]

(c) The amount of radioactivity of a sample of Americium-241 is 800 Bq. If the half-life of Americium-241 is 432 years, determine the amount of radioactivity of americium after 1728 years.

Radioactivity = _____
[2]

(d) Another isotope of Neptunium, Np-229, is able to undergo nuclear decay. **Fig. 8.1** shows the decay curve of a sample of Np-229.

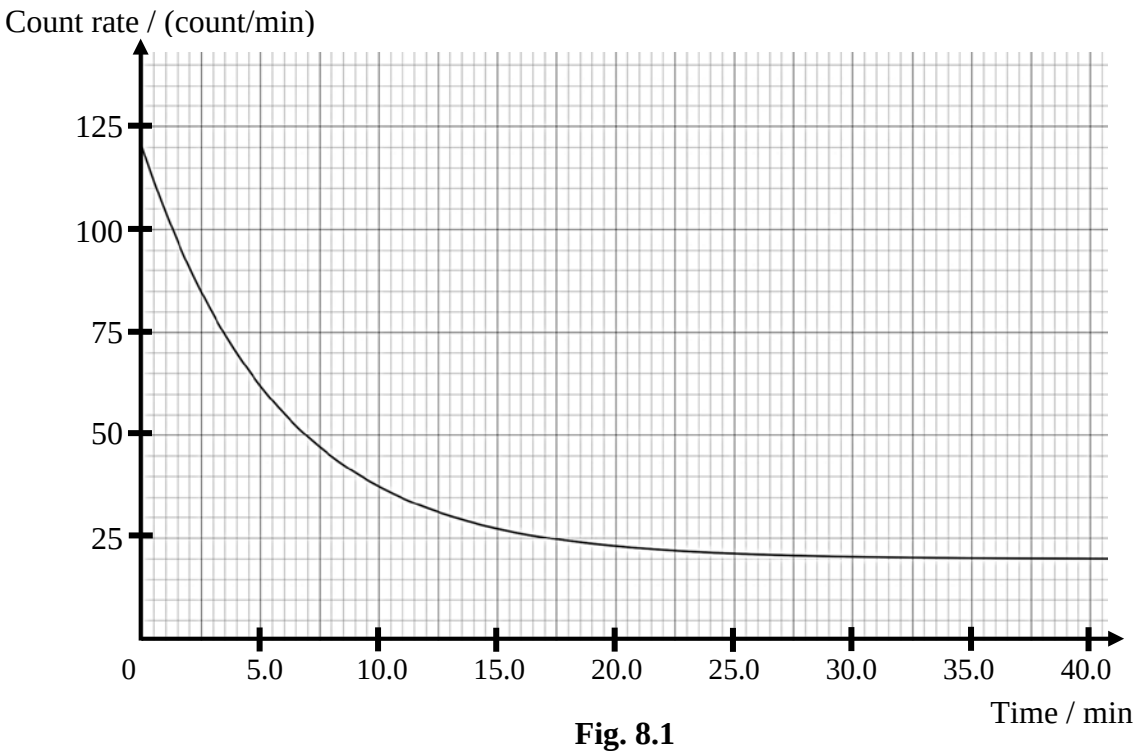


Fig. 8.1

There is some background radiation that contributes to the count rate in **Fig. 8.1**. All the radioactive Np-229 nuclei in the sample has fully decayed by 35.0 min.

With reference to **Fig. 8.1**, determine the count rate due to background radiation only.

Background count rate = _____

[1]

9 The components of the electromagnetic spectrum have different uses. Microwaves are used in cooking. Microwaves created inside the oven are reflected by the metal walls. They could pass through Pyrex glass as well as absorbed by foods.

Fig. 9.1

Fig. 9.1 shows a microwave oven used to heat soup. The container for the soup is a Pyrex glass bowl. The soup is mostly water. Microwaves passes through the Pyrex glass and are completely absorbed by a few centimetres of soup. As a result, microwaves do not reach the centre of the soup.

The instructions suggest that, after the microwave oven is turned off, the soup:
• is not stirred
• is left for some minutes so that the centre becomes hot.

The temperature of the Pyrex bowl of cold soup before heating is measured and the bowl of hot soup placed in the microwave after several minutes is collected.

Measurements and other data are:

temperature of Pyrex bowl of soup before heating = 26 °C
temperature of Pyrex bowl of soup after heating = 80 °C
specific heat capacity of soup = 4200 J / (kg °C)
specific heat capacity of glass bowl = 750 J / (kg °C)
mass of soup = 750 g
mass of glass bowl = 600 g

(a) State the name and describe in detail, each of the two processes by which thermal energy transfers throughout the soup after the microwave oven is turned off.

[4]

(b) Using the kinetic model, state and explain what happens to the internal store of the liquid particles in the soup as its temperature rises from 26 °C to 80 °C.

[2]

(c) Calculate the thermal energy (heat) gained by the soup from 26 °C to 80 °C.

Thermal energy = _____

[2]

(d) Assuming the thermal energy from the microwave oven is transferred to the Pyrex glass bowl and the soup at the same rate, which one do you think will increase in temperature faster? Explain your answer.

[2]

10 **Fig. 10.1a** and **Fig. 10.1b** shows the top and side views respectively of two aluminium plates mounted and fixed in position over a region of uniform magnetic field. The aluminium plates are connected to a d.c. power source and a switch. A copper rod **A** is placed perpendicularly across the top of the two mounted plates and is able to roll freely. Copper and aluminium are both non-magnetic materials and good electrical conductors.

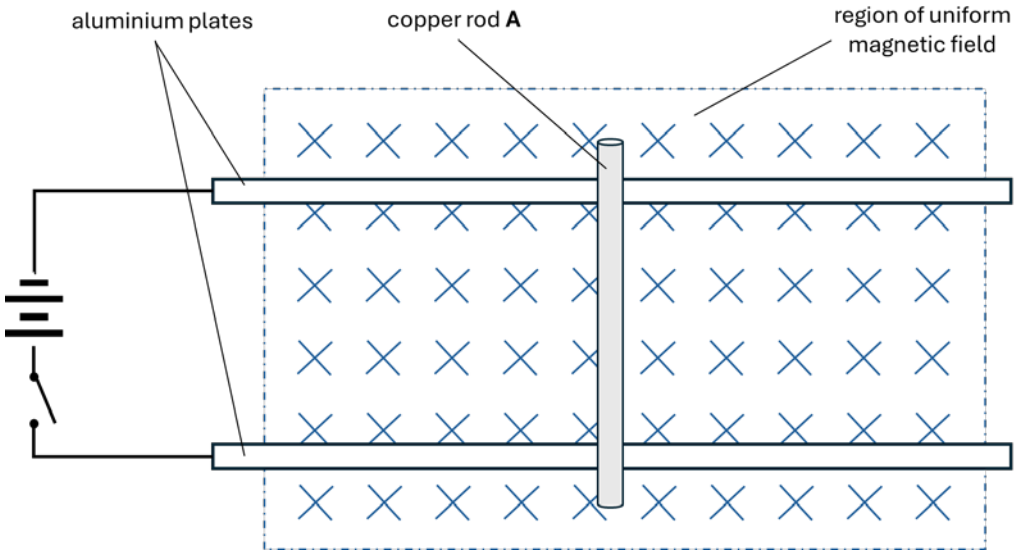


Fig. 10.1a (top view)

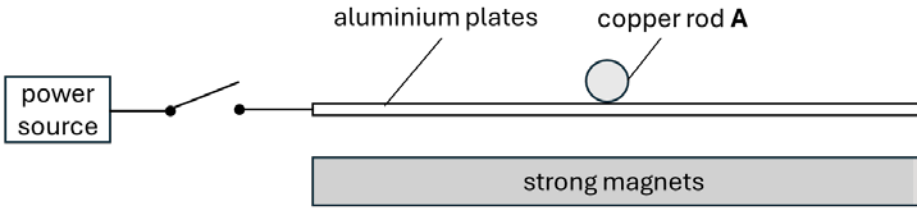


Fig. 10.1b (side view)

When the switch is closed, the copper rod moves.

(a) **(i)** Describe and explain what happens when the switch is closed.

[3]

(ii) The table below describes what happens to the direction and speed of the movement of the rod when the set-up in **Fig. 10.1a** and **Fig. 10.1b** is adjusted.

Complete the table with:

- "*no change*" or "*reverses*" for direction
- "*increases*" or "*decreases*" or "*no change*" for speed.

Adjustment to set-up	Direction of movement	Speed of movement
The current from the power source is increased	No change	
Both the direction of the uniform magnetic field **AND** the direction of the current from the power source are reversed		No change

[2]

(b) **Fig. 10.2** shows the cross-section of two parallel conductors placed near to each other. The currents in the conductors are flowing in the same direction.

Fig. 10.2

(i) Draw, on **Fig. 10.2**, the resultant magnetic field of the two current-carrying conductors. [2]

(ii) Hence indicate with an arrow the direction of the force experienced by each conductor (if any), and label each arrow "**F**". [1]

(c) Another copper rod **B** is placed on the mounted aluminium plates, on the right of copper rod **A**, as shown in **Fig. 10.3a** and **Fig. 10.3b**. The two rods are in close proximity.

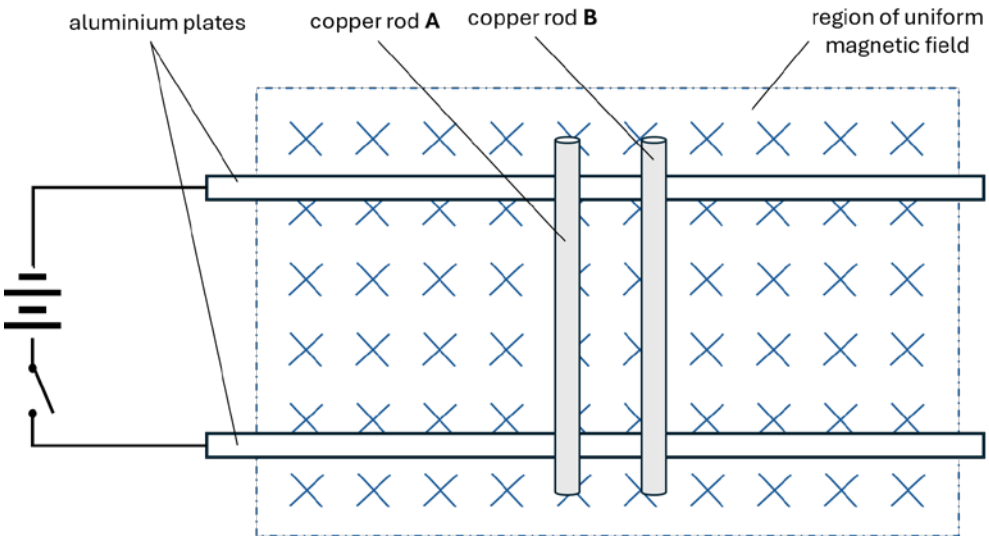


Fig. 10.3a (top view)

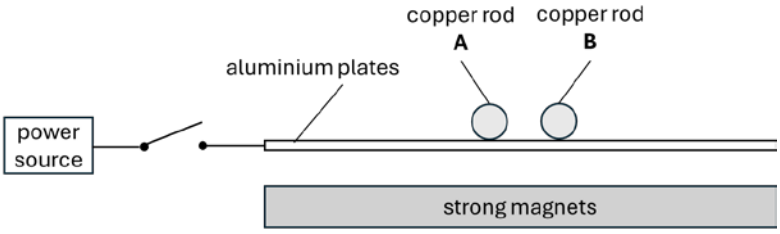


Fig. 10.3b (side view)

Using your answer from **(b)**, compare and explain the difference in movements of copper rods **A** and **B** when the switch is closed.

[2]

Section B

Answer only one of the two alternative questions in Question 11.

11 Either

11 A skydiver jumps from a hovering helicopter at a fix height above ground. His initial downwards acceleration is 10 m/s^2. The mass of the sky diver is 60 kg.

The total force of air resistance acting on the skydiver and open parachute changes with their speed, as shown in **Fig. 11.1**.

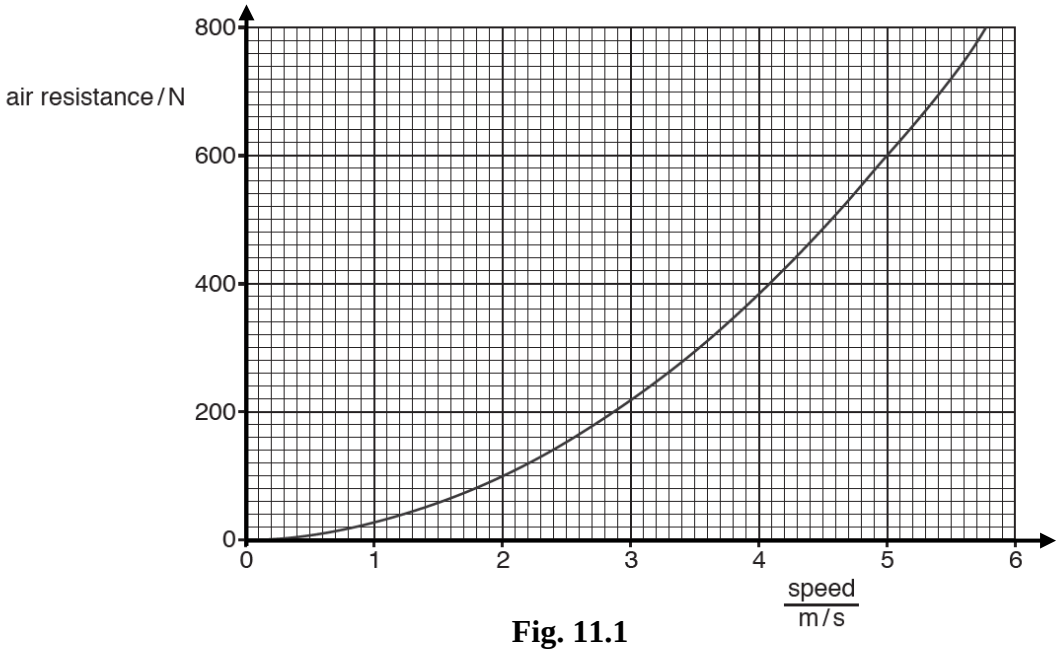


Fig. 11.1

(a) Explain, using ideas about the forces, why the skydiver's initial downward acceleration is 10 m/s^2.

[1]

(b) Draw the forces acting on the skydiver when his speed is 3.0 m/s. State the magnitude and direction of these forces using information from **Fig. 11.1**. [2]

Fig. 11.2

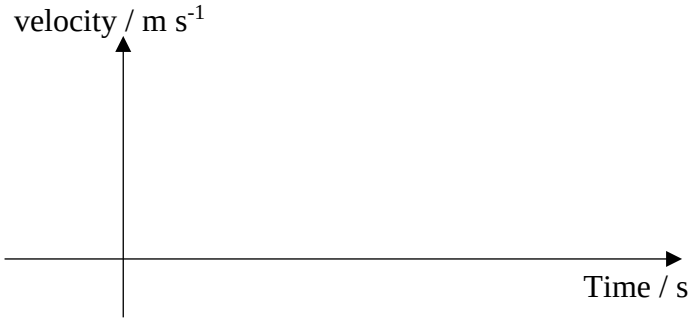
(c) After the parachute opens, the skydiver slows down to a terminal velocity.

Using **Fig. 11.1**,

(i) state what is meant by terminal velocity.

[1]

(ii) sketch a velocity-time graph to show the motion of the skydiver when he jumps from the hovering helicopter until he reaches terminal velocity.



[1]

(iii) determine the terminal velocity of the skydiver.

Terminal velocity = _____

[2]

(iv) calculate the resultant force acting on the skydiver when his speed is 5.4 m/s. Hence determine the magnitude and direction of his acceleration.

Resultant force = _____

Magnitude of acceleration = _____

Direction of acceleration = _____

[3]

11 Or

11 **Fig. 11.3** shows a transformer linking two circuits. The primary coil is connected to an a.c. power source which provides an alternating voltage of 240 V. The electrical appliance is connected to the secondary coil via transmission cables that have significant resistance. The transformer is assumed to be an ideal transformer with no energy losses.

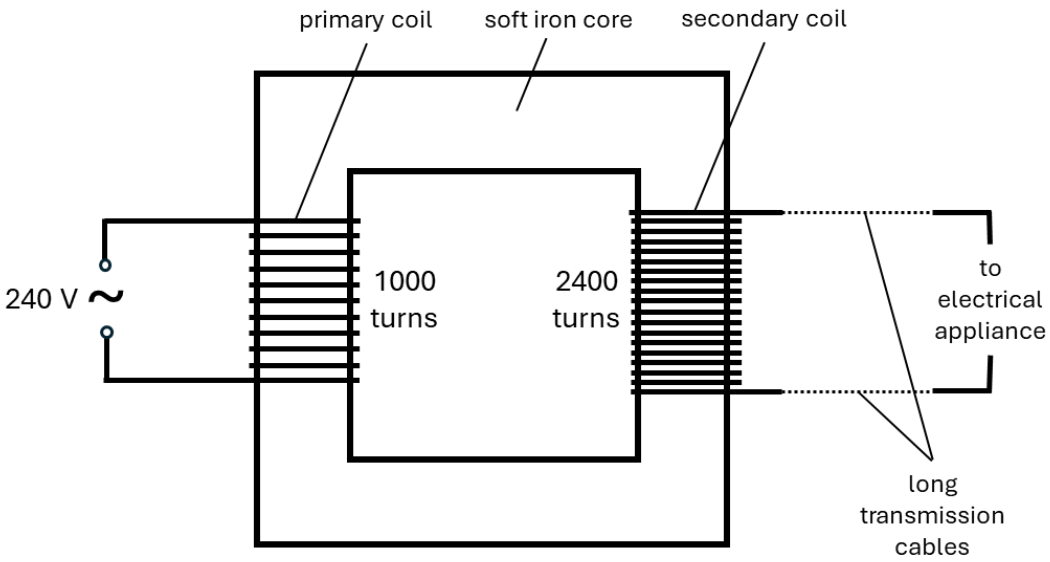


Fig. 11.3

(a) Explain how a transformer is able to generate an induced e.m.f. in the secondary coil from an alternating current flowing in the primary coil.

[3]

(b) The current in the primary coil is 6.00 A and the transmission cables have a total resistance of 24.0 Ω combined.

With reference to **Fig. 11.3**,

(i) calculate the output e.m.f. in the secondary coil.

Output e.m.f. = _____
[2]

(ii) determine the output current in the secondary coil.

Output current = _____
[2]

(iii) hence, calculate the power loss due to heating in the transmission cables.

Power loss = _____
[2]

(c) In reality, most transformers consist of a core that is made up of thin sheets of soft iron, laminated together by coats of lacquer (an electrical insulator).

Explain how this laminated design improves the efficiency of the transformer.

_____

_____
[1]

-End of Paper-