



XINMIN SECONDARY SCHOOL
新民中學
SEKOLAH MENENGAH XINMIN

Preliminary Examination 2026

CANDIDATE NAME

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CLASS

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INDEX NUMBER

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PHYSICS

6091/02

Paper 2

Secondary 4 Express

28 AUG 2026

Setter: Mr. Koh Tat Siang

Vetter: Mr. Zhuang Haoyang

1 hour 45 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number on 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.

Write your answers in the spaces provided.

Section B

Answer **one** question.

Write your answers in the spaces provided.

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.

For Examiner's Use		
Section A		70
Section B	Q	10
Total		80
Parent's Signature		

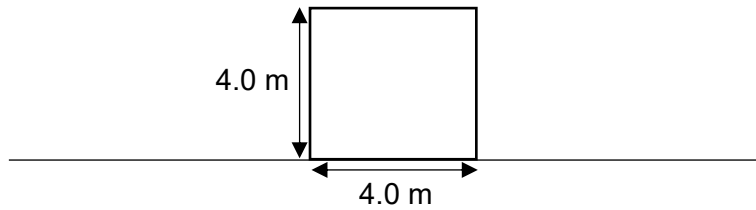
This document consists of **20** printed pages and **0** blank page(s).

[Turn over

Section A [70 marks]Answer **all** questions.

Write your answers in the spaces provided.

- 1 Fig. 1.1 shows a cube with sides of 4.0 m placed on a flat horizontal surface. The cube is made of material **X**. Take g to be 10 m/s^2 .

**Fig. 1.1**

- (a) The weight of the cube is 2400 N.
Calculate the density of the material **X**.

density = [2]

- (b) State and explain what would happen if the cube is placed into a tank of water.
The density of water is 1.0 g/cm^3 .

.....

.....

..... [2]

- (c) Fig. 1.2 shows that a smaller cube of sides of 1.0 m is cut away and replaced with a cube of the same size but made of material Y.

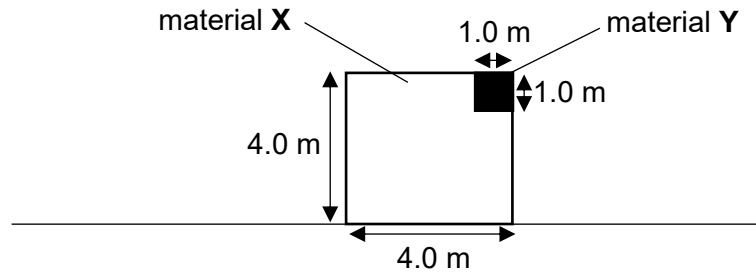


Fig. 1.2

The density of material Y is 20 kg/m^3 .

Calculate the effective density of the object shown in Fig. 1.2.

density = [3]

[Total: 7]

- 2 Fig. 2.1 shows a system of three masses held in equilibrium. When the tensions, T_1 , T_2 and T_3 , are balanced, the angle between T_1 and the vertical is 69° and the angle between T_2 and the vertical is 44° .

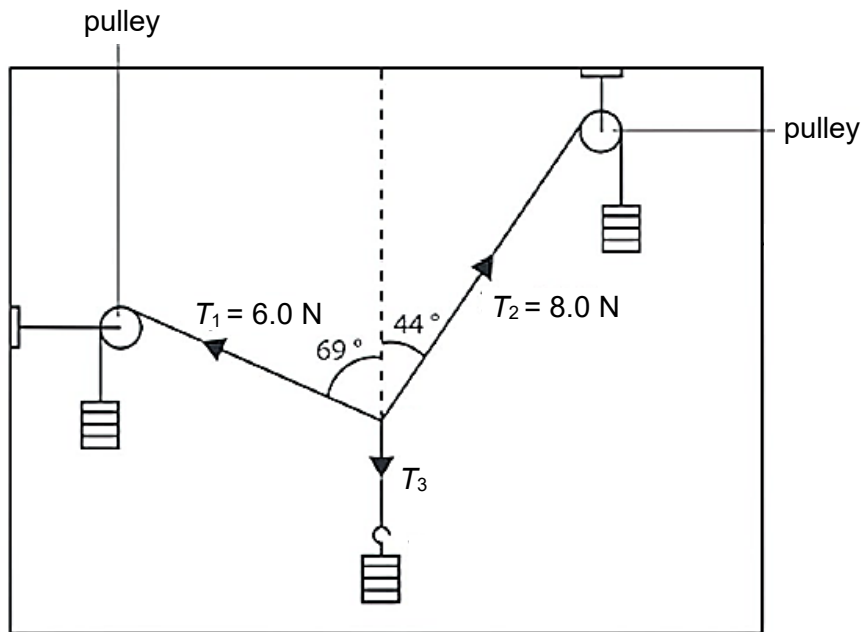


Fig. 2.1 (not to scale)

By means of a scaled diagram drawn in the space below, determine the magnitude of T_3

Scale:

magnitude of T_3 = [4]

[Total: 4]

- 3 Fig. 3.1 shows a steelyard. The steelyard consists of a steel rod **PS** and a scale pan. For this question consider the steelyard as a single object.

At the end **P**, the scale pan is used to hold additional objects whose total weight is to be measured. The steelyard is suspended at **Q** and a weight of 2.0 N can be placed anywhere between **R** and **S**.

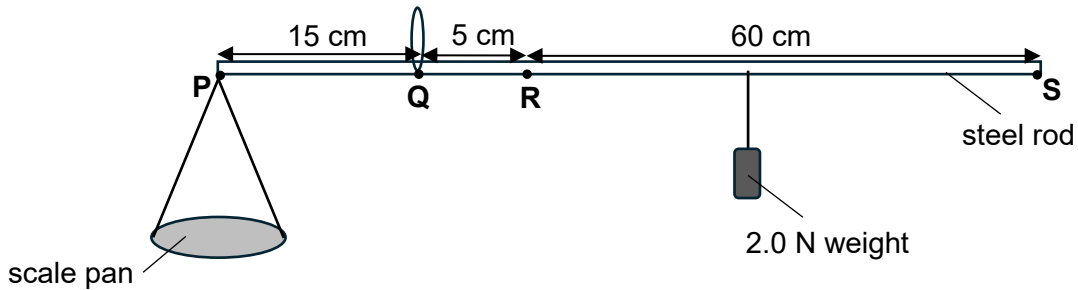


Fig. 3.1 (not to scale)

When the pan is empty, the 2.0 N weight balances the steelyard at point **R**.

- (a) Explain, using the principle of moments, why the weight of the steelyard (which consists of the scale pan and steel rod as one object) must be acting between **P** and **Q**.

.....

 [2]

- (b) Determine the moment due to the weight of the steelyard. Clearly stated its magnitude and direction.

magnitude of moment =

direction of moment = [2]

- (c) Calculate the maximum weight of additional objects that this steelyard can measure.

weight = [2]

[Total: 6]

- 4 A stone is thrown into a calm pond. When it hits the water surface at $t = 0.0$ s, it causes the water surface to vibrate and form a water wave on the surface of the pond moving away from the point where the stone hits the water surface.

Fig. 4.1 shows at $t = 4.0$ s, the displacement, d_1 of the water surface from its rest position against the distance, d_2 from the point where the stone hits the water surface.

displacement, d_1 /cm

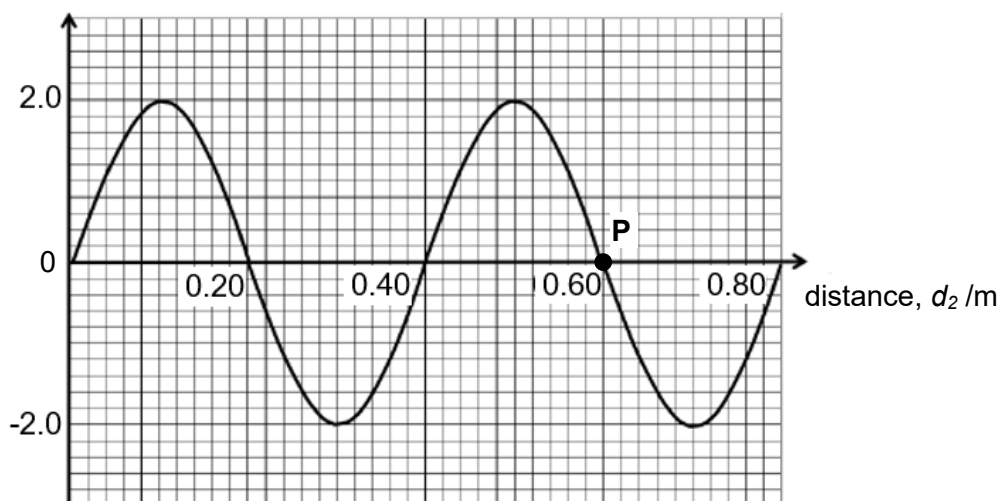


Fig. 4.1

- (a) It takes 8.0 s for the water wave to complete 4 complete oscillations.

Determine the speed of the water wave.

speed = [3]

- (b) At $t = 4.0$ s, a leaf is at position **P** as shown in Fig. 4.1.
State the position of the leaf at $t = 5.5$ s and describe the movement of leaf from $t = 4.0$ s to $t = 5.5$ s.

At $t = 5.5$ s, leaf would be at:

$d_1 = \dots\dots\dots$ and $d_2 = \dots\dots\dots$

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

[Total: 6]

- 5 (a) Fig. 5.1 shows a circuit diagram.

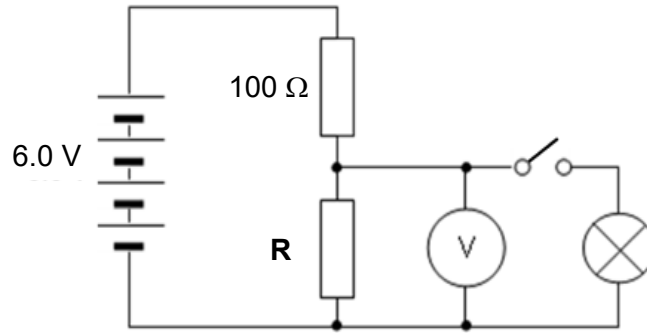


Fig. 5.1

When the switch is not closed, the voltmeter shows a reading of 3.5 V.
Calculate the resistance of resistor R.

resistance = [2]

- (b) The $100\ \Omega$ resistor is replaced with a thermistor and the switch is closed as shown in Fig. 5.2.
Fig. 5.3 shows how the resistance of the thermistor varies with temperature.

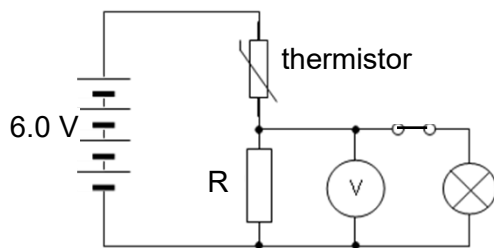


Fig. 5.2

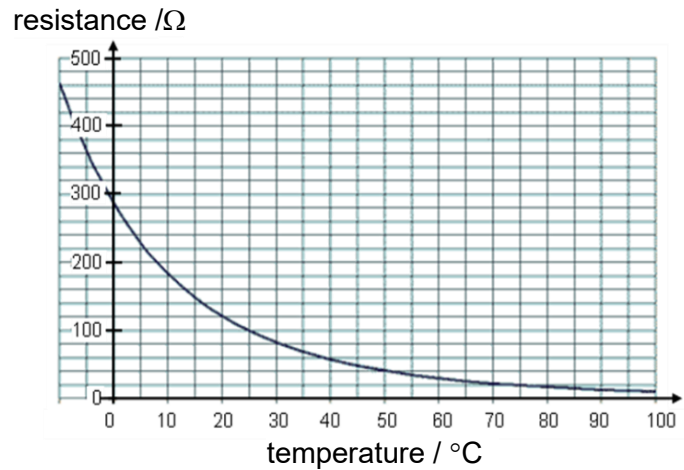


Fig. 5.3

Describe and explain how the brightness of the bulb in Fig 5.2 will change as the temperature increases from $25\ ^\circ\text{C}$ to $40\ ^\circ\text{C}$.

.....

 [2]

[Total: 4]

- 6 Fig. 6.1 shows part of the mains electric circuit in a house.

Three lamps **A**, **B**, and **C**, each rated '60 W, 220 V' are connected in parallel with each other.

An electric fan with a maximum capacity rated at '1000 W, 220 V' is connected to the mains supply as well. The mains supply is 220 V.

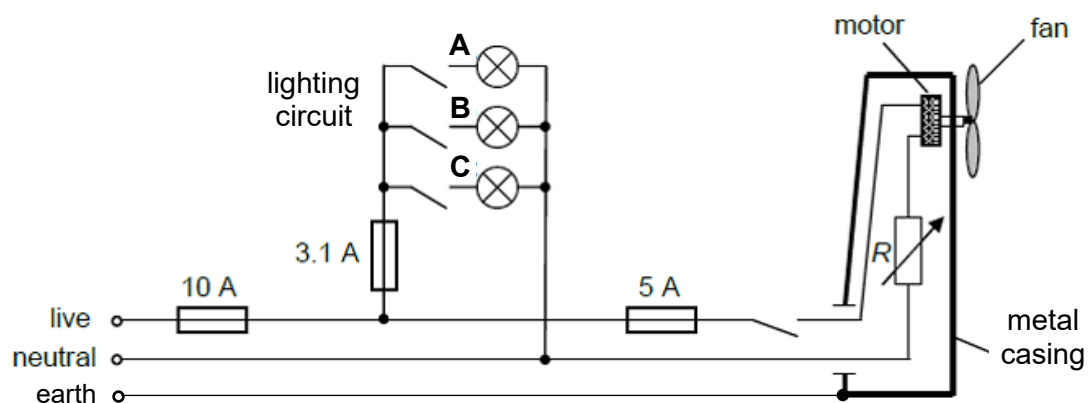


Fig. 6.1

- (a) Explain why the 10 A, 3.1 A and 5 A fuses are all placed on the live wire.

..... [1]

- (b) The homeowner wishes to connect more lamps in parallel to lamps **A**, **B** and **C** in the lighting circuit.
Determine how many more lamps can be safely connected.

number of lamps = [2]

- (c) Explain the function of the earth wire connected to the metal casing of the electric fan.

..... [2]

[Total: 5]

7 Fig. 7.1 shows a circuit with a solenoid.

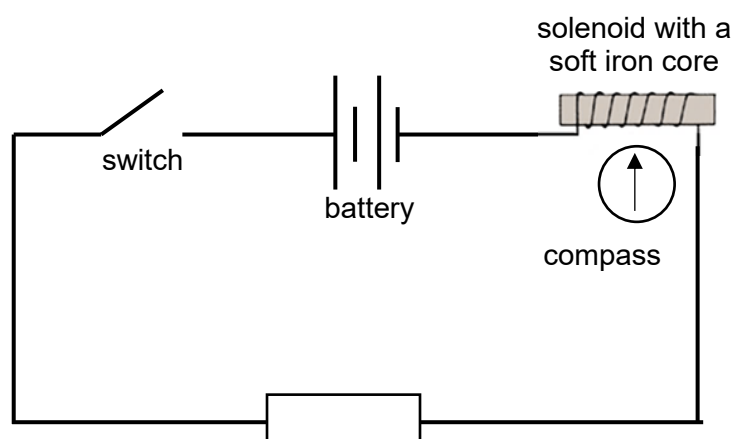


Fig. 7.1

The switch is closed.

- (a) On Fig. 7.1, draw an arrowhead on the coil of the solenoid to show the direction of current flowing in the solenoid.

[1]

- (b) Hence or otherwise, draw the magnetic field produced by the solenoid.



Fig. 7.2

[2]

- (c) State and explain what happens to the compass needle.

.....

[2]

[Total: 5]

- 8 (a) Fig. 8.1 shows a straight wire **AB** being moved across a magnetic field. A galvanometer is connected across the wire **AB**.

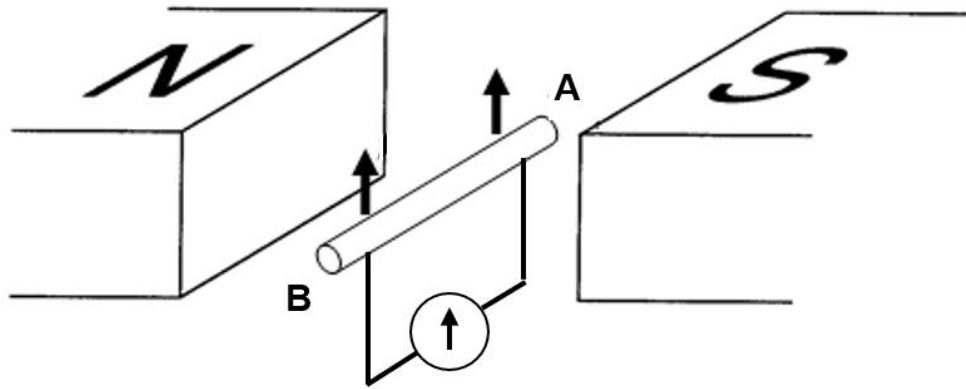


Fig. 8.1

As wire **AB** is being moved upwards between the magnetic poles, the needle of the galvanometer connected across wire **AB** deflects to the right.

- (i) State the direction of induced current on wire **AB** as it is being moved upwards between the magnetic poles and explain how you determine the direction.

.....

 [2]

- (ii) State and explain what happens to the needle of the galvanometer when the wire is held stationary between the magnetic poles.

.....

 [1]

- (b) The wire **AB** is then replaced by a single loop of wire, which is rotated at a constant speed between the magnetic poles, as shown in Fig. 8.2.

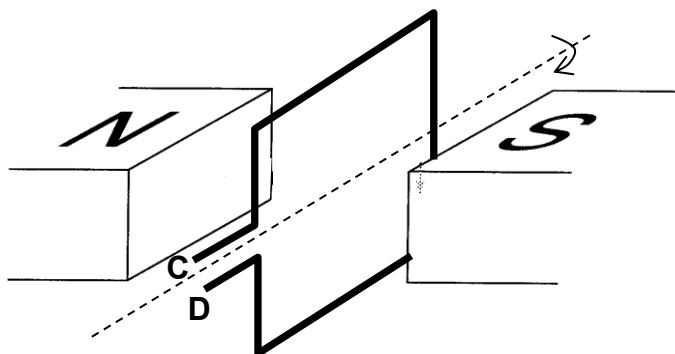
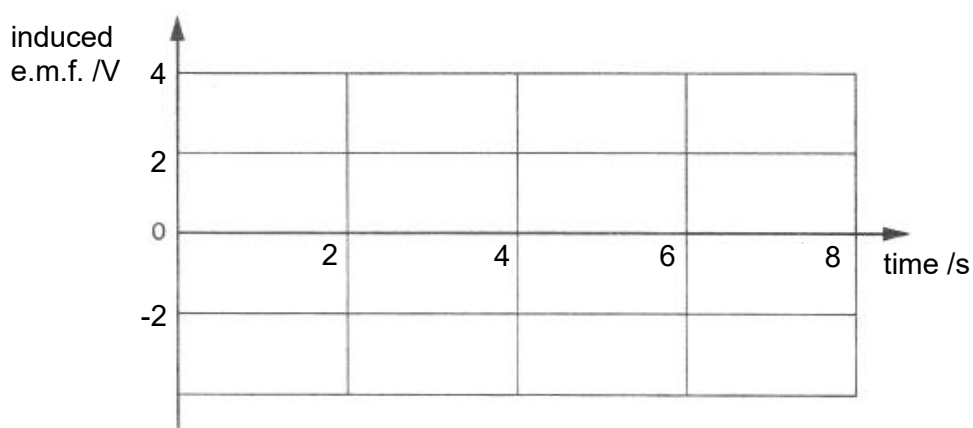


Fig. 8.2

- (i) The coil takes 4 s to make 1 complete rotation. The maximum induced e.m.f across **CD** is 2 V.

On Fig. 8.3, sketch a graph of the induced e.m.f. across **CD**, the two ends of the loop, against time when the coil is rotated from the initial position, as shown in Fig. 8.2. Label it **X**.



[2]

Fig. 8.3

- (ii) Sketch another graph of the induced e.m.f across **CD** when the coil is rotated with twice the speed. Label it **Y**.

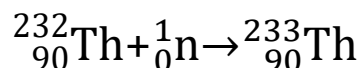
[2]

[Total: 7]

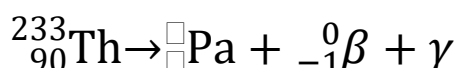
- 10** Thorium small modular reactors (SMRs) are one of the newer experimental types of nuclear fission reactors. Theoretically, these type of reactors offer greater protection against reactor meltdown, uses a more abundant fuel, and are more efficient than traditional fission reactors.

The nuclear reaction that the Thorium SMRs uses is more complex than the traditional fission reaction and can be broken down into four steps:

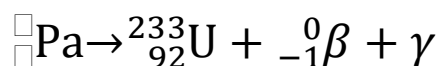
Step 1: Neutron Capture: Thorium-232 absorbs a neutron becoming Thorium-233



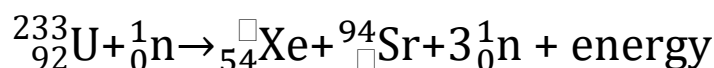
Step 2: Beta Decay: Thorium-233 undergoes beta decay with gamma emission to form Protactinium (Pa)



Step 3: Second Beta Decay: Protactinium undergoes beta decay with gamma emission to form Uranium (U)



Step 4: Nuclear Fission



- (a) State the nature of a beta (β) particle.

..... [1]

- (b) Determine missing nucleon number and/or proton numbers of the following:

- (i) Protactinium (Pa)



- (ii) Xe



- (iii) Sr



- (c) The Xenon (Xe) produced in Step 4 has a half-life of 75 seconds and decays into a stable nucleus.

Estimate the time it would take for a sample of Xenon to be reduced to less than 1% of its original number of nuclei.

time = [2]

[Total: 6]

- 10 A boy drops a ball from rest at time $t = 0.0$ s.
The ball falls vertically and hits a rubber mat at $t = 1.5$ s with a speed of 15 m/s.
It rebounds vertically upwards and at $t = 1.6$ s, had just left contact with the mat and has a speed of 12 m/s.
At $t = 2.8$ s, the ball reaches the highest point of its rebound.

Assume air resistance is negligible.

- (a) On Fig. 10.1, complete the sketch of the velocity-time graph for this ball.
Label the axes with all relevant values.

[2]

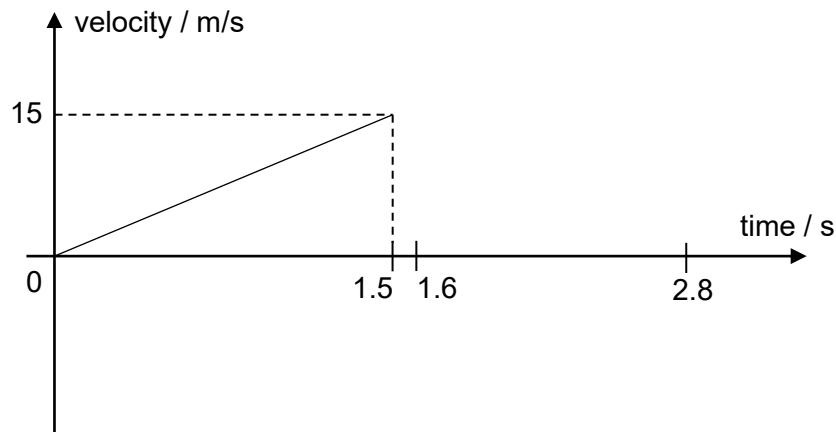


Fig. 10.1

- (b) Define *acceleration*.

.....
.....

[1]

- (c) Calculate the acceleration of the ball between $t = 1.5$ s and $t = 1.6$ s.

acceleration = [2]

- (d) The gravitational acceleration, g experienced by the ball is 10 m/s^2 .
Using your understanding for forces, explain why the acceleration of the ball
between $t = 0.0$ s and $t = 1.5$ s is 10 m/s^2 .

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

- (e) Show, with appropriate working, that the maximum rebound height of the ball is
shorter than the initial height the ball is released from.

[3]

[Total: 10]

- 11 As the demand for artificial intelligence (AI) services increases globally, more data centres need to be built to house the servers that AI platforms run on.

These servers use electricity and generate large amounts of heat. To ensure the servers do not overheat, a cooling system made from a network of pipes is connected to the servers. Coolant fluid is pumped through the pipes to transfer the heat produced by the servers away.

Normally, this heat is allowed to be lost to the environment, but an innovative company decided to use the heat produced to supply greenhouses in places with cold climates.

Fig. 11.1 shows a simplified diagram of their prototype setup.

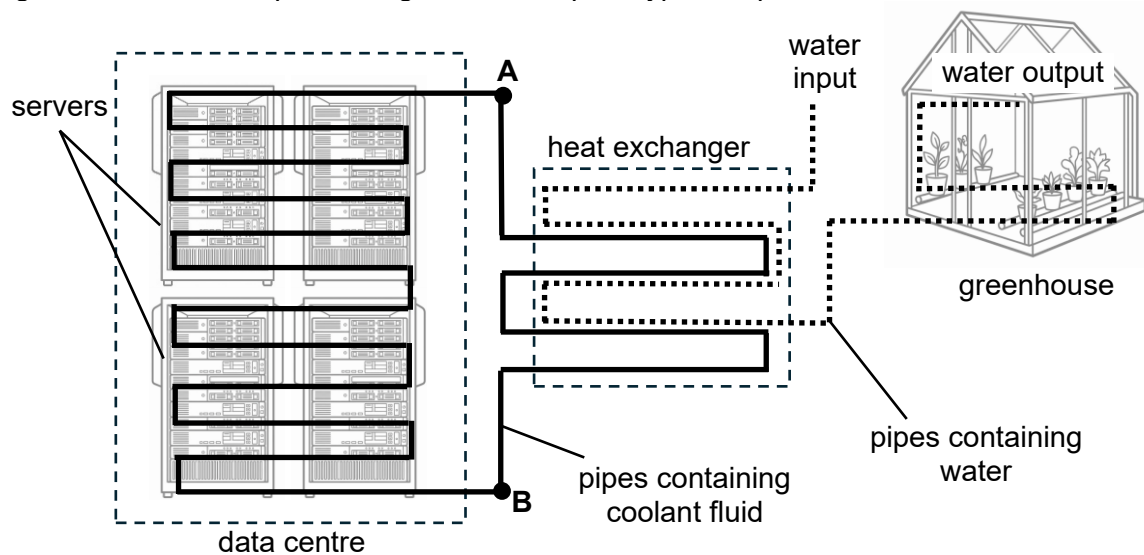


Fig. 11.1

Information and data of the prototype setup is listed below:

number of servers in the data centre: 4 servers
 optimal temperature of servers: 25 °C
 server power consumption: 40 kW – 120 kW
 server potential difference supply: 400 V
 coolant fluid temperature at point **A**: 10 °C
 coolant fluid temperature at point **B**: 25 °C
 coolant fluid flow rate: 16 kg/s
 water flow rate: 7.6 kg/s
 specific heat capacity of water: 4200 J / (kg °C)

- (a) State the *principle of conservation of energy*.

.....

[1]

- (b) All energy electrically transferred to the servers is eventually transferred to the internal store of the server or transferred away by heating. The servers in the data centre are kept at constant temperature of 25 °C when the servers are running at maximum capacity.
- (i) Calculate the amount of energy per second that must be removed by the cooling system to keep the servers at 25 °C.

energy per second = J s⁻¹ [2]

- (ii) Determine the specific heat capacity of the coolant fluid.

specific heat capacity = [2]

- (c) Suggest from the following list of materials below which material is best suited to used for the pipes in the heat exchanger.

The materials can be used once, more than once, or not at all.

copper, painted black
copper, painted white

plastic, painted black
plastic, painted white

pipe containing coolant fluid:

pipe containing water: [2]

- (d) Explain why the pipes in the heat exchanger is arranged as shown in Fig. 11.1.

.....
.....

..... [2]

- (e) Suggest one change that can be made to the heat exchanger to improve its efficiency.

.....
.....

..... [1]

[Total: 10]

Section B [10 marks]

Answer **one** question from this section.
Write your answers in the spaces provided.

- 12** Fig. 12.1 shows a cyclist riding his bicycle over a hill.

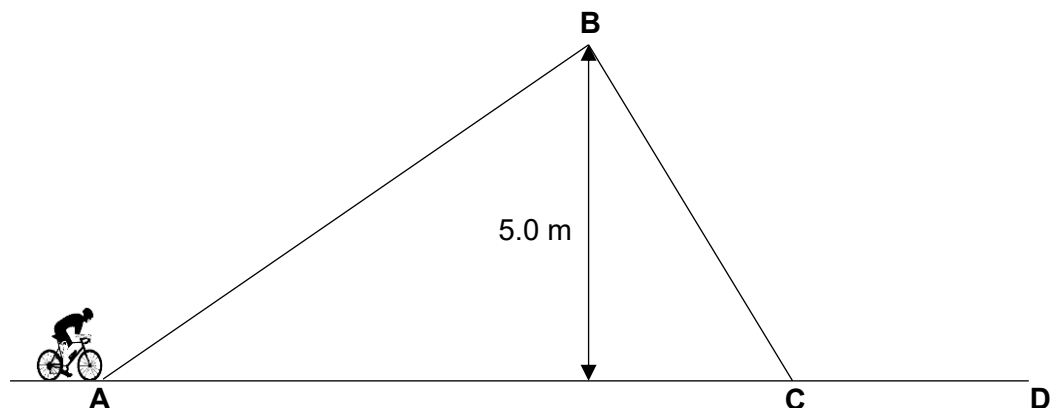


Fig. 12.1

The cyclist and his bicycle have a speed of 4.0 m/s at point **A** and the mass of the cyclist and his bicycle is 80 kg. Take $g = 10 \text{ N/kg}$. Ignore the effects of air resistance and friction.

From **A** to **B** the cyclist continues to pedal and has a speed of 5.0 m/s at point **B**.

- (a)** Calculate the gain in energy in the gravitational potential store of cyclist and his bicycle from **A** to **B**.

gain in energy in gravitational potential store = [1]

- (b)** Calculate the change in energy in the kinetic store of the cyclist and his bicycle from **A** to **B**.

change in energy in kinetic store = [2]

- (c)** Describe, using your understanding of energy stores and transfer, how energy is transferred for the cyclist and his bicycle from **A** to **B**. State the transfer pathway(s) clearly.

.....

 [2]

- (d) The cyclist stops pedalling when he reaches **B** and allows the bicycle to freely roll down the hill from **B** to **C**.

At **C**, he applies the bicycle's brakes and exerts a frictional force of 500 N. The bicycle slows and comes to a stop at **D**.

- (i) Calculate the distance from **C** to **D**.

distance = [3]

- (ii) Give two suggestions what happens to the energy in the kinetic store of the cyclist and his bicycle from **C** to **D**.

.....

.....

..... [2]

[Total: 10]

- 13 Fig. 13.1 shows an optical cable consisting of an optically denser core surrounded by an optically less dense cladding.

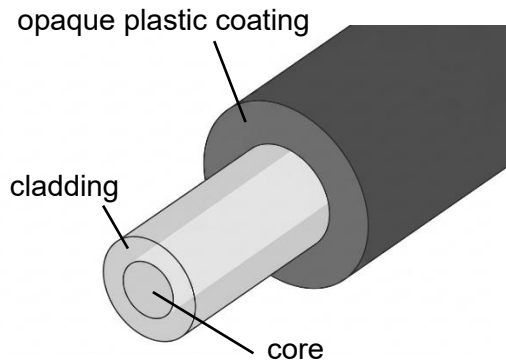


Fig. 13.1

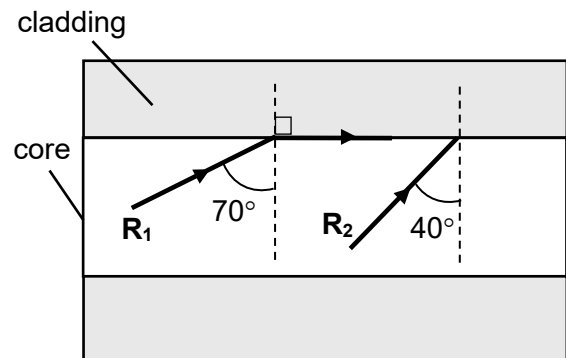


Fig. 13.2

Fig. 13.2 shows a lengthwise cross-section of the optical cable and the path of two light rays, R_1 and R_2 .

Assume that the refractive index of the cladding is 1.0.

- (a) Calculate the refractive index of the core.

refractive index = [2]

- (b) Draw on Fig. 13.2 the path of ray R_2 after it is incident on the boundary between the core and the cladding. Ensure that you

- show any working in the space below
- label any significant angle on Fig. 13.2

[2]

- (c) The speed of light in the cladding is 3.0×10^8 m/s.
Calculate the speed of light in the core.

speed of light = [1]

- (d) Optical fibres are able to transmit information as pulses of light from one end to the other, even when the fibre is slightly bent. This is possible as total internal reflection keeps the pulses of light from escaping the optical fibre.

- (i) Explain what is meant by *total internal reflection*.

.....

.....

.....

..... [2]

- (ii) A student suggested the following:

“The core should have as high a refractive index as possible.”

Suggest one advantage and one disadvantage of having a core that has a high refractive index.

1. Advantage:

.....

.....

..... [2]

2. Disadvantage:

.....

.....

..... [1]

[Total: 10]

End of paper