



22126511

**PHYSICS
STANDARD LEVEL
PAPER 2**

Thursday 10 May 2012 (afternoon)

1 hour 15 minutes

Candidate session number

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Examination code

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INSTRUCTIONS TO CANDIDATES

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Section A: answer all questions.
- Section B: answer one question.
- Write your answers in the boxes provided.
- A calculator is required for this paper.
- A clean copy of the **Physics Data Booklet** is required for this paper.
- The maximum mark for this examination paper is [50 marks].



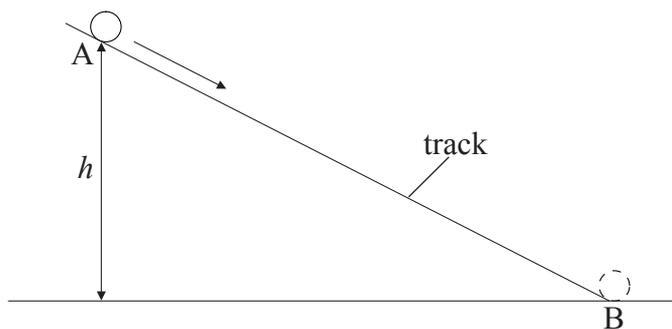
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SECTION A

Answer **all** questions. Write your answers in the boxes provided.

A1. Data analysis question.

A small sphere rolls down a track of constant length AB. The sphere is released from rest at A. The time t that the sphere takes to roll from A to B is measured for different values of height h .

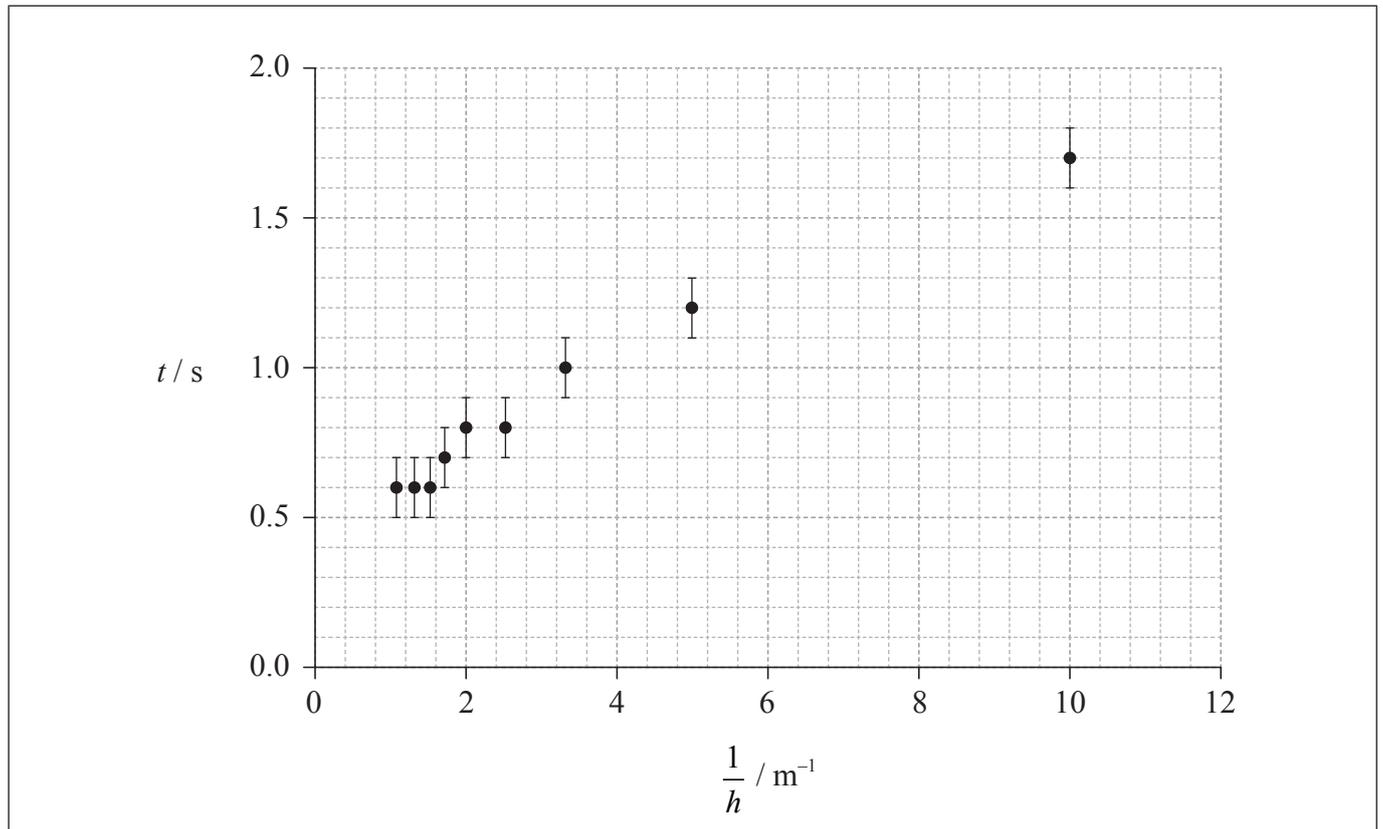


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(Question A1 continued)

A student suggests that t is proportional to $\frac{1}{h}$. To test this hypothesis a graph of t against $\frac{1}{h}$ is plotted as shown on the axes below. The uncertainty in t is shown and the uncertainty in $\frac{1}{h}$ is negligible.



(a) (i) Draw the straight line that best fits the data. [1]

(ii) State why the data do not support the hypothesis. [1]

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(Question A1 continued)

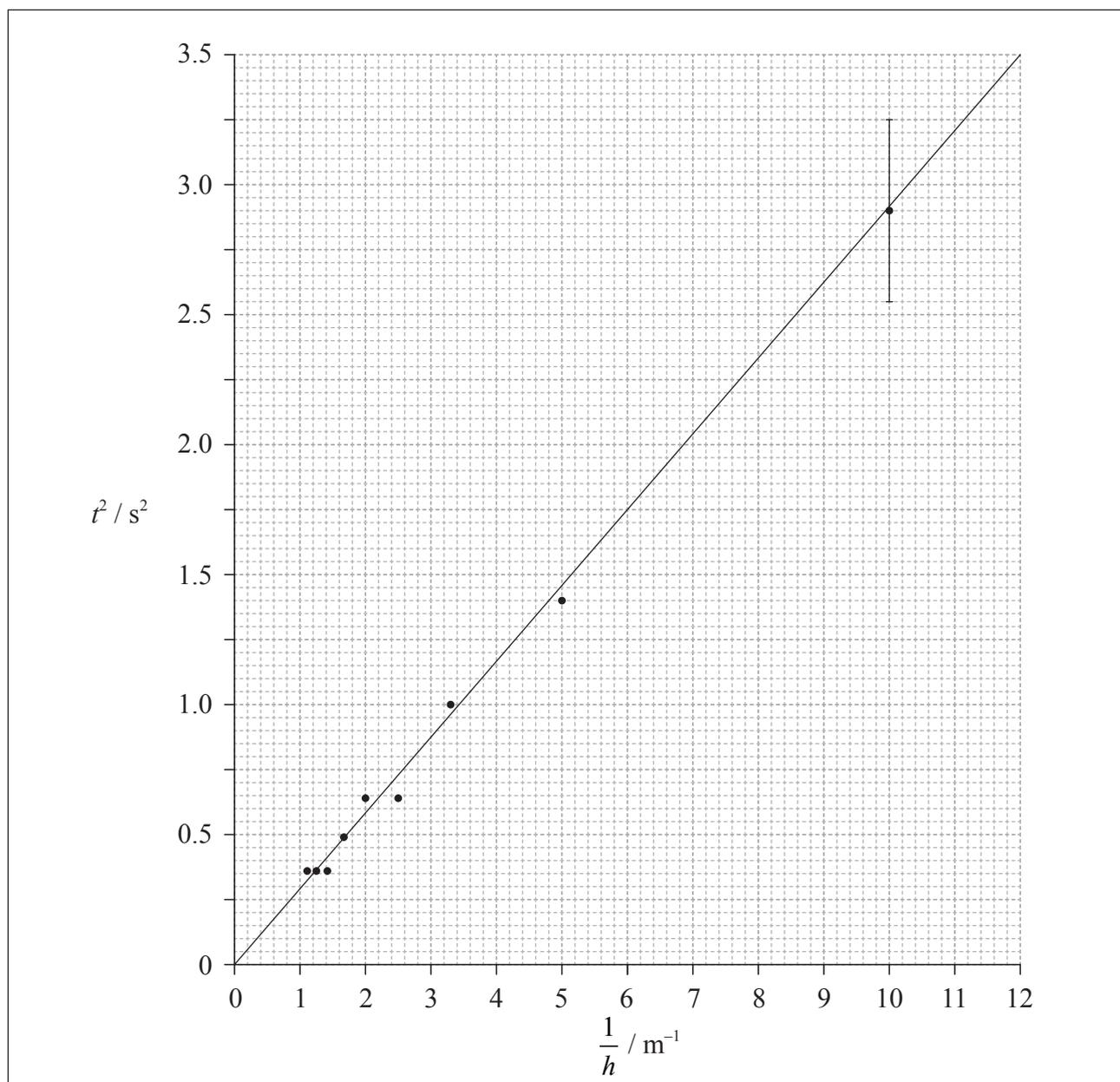
- (b) Another student suggests that the relationship between t and h is of the form

$$t = k\sqrt{\frac{1}{h}}$$

where k is a constant.

To test whether or not the data support this relationship, a graph of t^2 against $\frac{1}{h}$ is plotted as shown below.

The best-fit line takes into account the uncertainties for all data points.



(This question continues on the following page)



(Question A1 continued)

The uncertainty in t^2 for the data point where $\frac{1}{h} = 10.0 \text{ m}^{-1}$ is shown as an error bar on the graph.

- (i) State the value of the uncertainty in t^2 for $\frac{1}{h} = 10.0 \text{ m}^{-1}$. [1]

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- (ii) Calculate the uncertainty in t^2 when $t = 0.8 \pm 0.1 \text{ s}$. Give your answer to an appropriate number of significant digits. [4]

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- (iii) Use the graph to determine the value of k . Do not calculate its uncertainty. [3]

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- (iv) State the unit of k . [1]

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A2. This question is about the greenhouse effect.

The following data are available for use in this question:

Quantity	Symbol	Value
Power emitted by the Sun	P	$3.8 \times 10^{26} \text{ W}$
Distance from the Sun to the Earth	d	$1.5 \times 10^{11} \text{ m}$
Radius of the Earth	r	$6.4 \times 10^6 \text{ m}$
Albedo of the Earth's atmosphere	α	0.31
Stefan-Boltzmann constant	σ	$5.7 \times 10^{-8} \text{ Wm}^{-2}\text{K}^{-4}$

(a) Explain why the power absorbed by the Earth is

$$\frac{P}{4\pi d^2} \times (1 - \alpha) \times \pi r^2 \quad [3]$$

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(Question A2 continued)

- (b) The equation in (a) leads to the following expression which can be used to predict the Earth's average surface temperature T .

$$T = \sqrt[4]{\frac{(1-\alpha)P}{16\pi\sigma d^2}}$$

- (i) Calculate the predicted temperature of the Earth. [2]

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- (ii) Explain why the actual average surface temperature of the Earth is in fact higher than the answer to (b)(i). [2]

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A3. This question is about thermal energy transfer.

A hot piece of iron is placed into a container of cold water. After a time the iron and water reach thermal equilibrium. The heat capacity of the container is negligible.

(a) Define *specific heat capacity*. [2]

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(b) The following data are available.

Mass of water	= 0.35 kg
Mass of iron	= 0.58 kg
Specific heat capacity of water	= 4200 Jkg ⁻¹ K ⁻¹
Initial temperature of water	= 20 °C
Final temperature of water	= 44 °C
Initial temperature of iron	= 180 °C

(i) Determine the specific heat capacity of iron. [3]

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(ii) Explain why the value calculated in (b)(i) is likely to be different from the accepted value. [2]

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SECTION B

*This section consists of three questions: B1, B2 and B3. Answer **one** question. Write your answers in the boxes provided.*

B1. This question is in **two** parts. **Part 1** is about wind power. **Part 2** is about radioactive decay.

Part 1 Wind power

(a) Outline in terms of energy changes how electrical energy is obtained from the energy of wind. [2]

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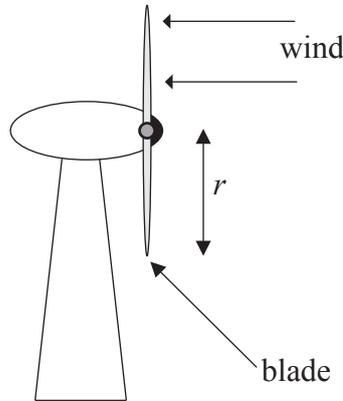
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(Question B1, part 1 continued)

- (b) Air of density ρ and speed v passes normally through a wind turbine of blade length r as shown below.



- (i) Deduce that the kinetic energy per unit time of the air incident on the turbine is

$$\frac{1}{2} \pi \rho r^2 v^3 \quad [3]$$

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- (ii) State **two** reasons why it is impossible to convert all the available energy of the wind to electrical energy. [2]

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(Question B1, part 1 continued)

- (c) Air is incident normally on a wind turbine and passes through the turbine blades without changing direction. The following data are available.

Density of air entering turbine = 1.1 kg m^{-3}
Density of air leaving turbine = 2.2 kg m^{-3}
Speed of air entering turbine = 9.8 m s^{-1}
Speed of air leaving turbine = 4.6 m s^{-1}
Blade length = 25 m

Determine the power extracted from the air by the turbine.

[3]

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(Question B1, part 1 continued)

- (d) A different wind turbine has a mechanical input power of $3.0 \times 10^5 \text{ W}$ and generates an electrical power output of $1.0 \times 10^5 \text{ W}$. On the grid below, construct and label a Sankey diagram for this wind turbine. [3]

- (e) Outline **one** advantage and **one** disadvantage of using wind turbines to generate electrical energy, as compared to using fossil fuels. [2]

Advantage:

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Disadvantage:

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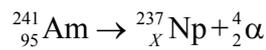
(Question B1 continued)

Part 2 Radioactive decay

- (a) Describe the phenomenon of natural radioactive decay. [3]

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- (b) A nucleus of americium-241 (Am-241) decays into a nucleus of neptunium-237 (Np-237) in the following reaction.



- (i) State the value of X . [1]

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- (ii) Explain in terms of mass why energy is released in the reaction in (b). [2]

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(Question B1, part 2 continued)

(iii) Define *binding energy* of a nucleus. [1]

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(iv) The following data are available.

Nuclide	Binding energy per nucleon / MeV
americium-241	7.54
neptunium-237	7.58
helium-4	7.07

Determine the energy released in the reaction in (b). [3]

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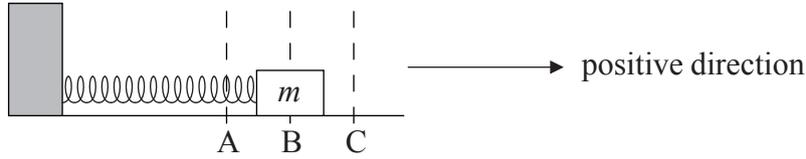
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B2. This question is in **two** parts. **Part 1** is about simple harmonic motion and the superposition of waves. **Part 2** is about gravitational fields.

Part 1 Simple harmonic motion and the superposition of waves

An object of mass m is placed on a frictionless surface and attached to a light horizontal spring. The other end of the spring is fixed.

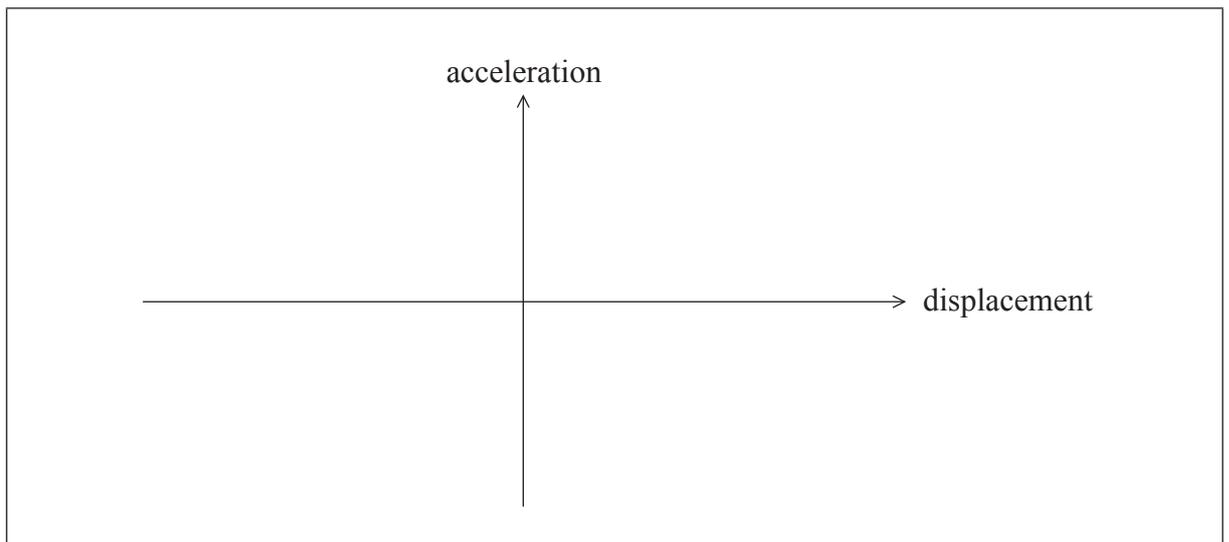


The equilibrium position is at B. The direction B to C is taken to be positive. The object is released from position A and executes simple harmonic motion between positions A and C.

(a) Define *simple harmonic motion*. [2]

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(b) (i) On the axes below, sketch a graph to show how the acceleration of the mass varies with displacement from the equilibrium position B. [2]



(ii) On your graph, label the points that correspond to the positions A, B and C. [1]

(This question continues on the following page)



(Question B2, part 1 continued)

- (c) (i) On the axes below, sketch a graph to show how the velocity of the mass varies with time from the moment of release from A until the mass returns to A for the first time. [2]



- (ii) On your graph, label the points that correspond to the positions A, B and C. [1]

- (d) The period of oscillation is 0.20 s and the distance from A to B is 0.040 m. Determine the maximum speed of the mass. [3]

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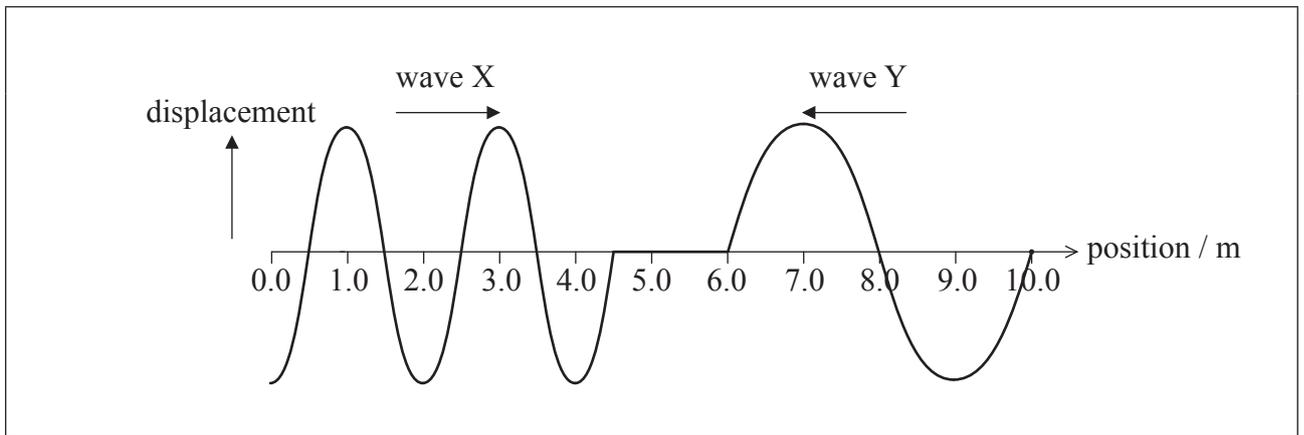


(Question B2, part 1 continued)

- (e) A long spring is stretched so that it has a length of 10.0 m. Both ends are made to oscillate with simple harmonic motion so that transverse waves of equal amplitude but different frequency are generated.

Wave X, travelling from left to right, has wavelength 2.0 m, and wave Y, travelling from right to left, has wavelength 4.0 m. Both waves move along the spring at speed 10.0 ms^{-1} .

The diagram below shows the waves at an instant in time.



- (i) State the principle of superposition as applied to waves. [2]

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- (ii) By drawing on the diagram or otherwise, calculate the position at which the resultant wave will have maximum displacement 0.20 s later. [2]

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(Question B2 continued)

Part 2 Gravitational fields

- (a) State Newton’s universal law of gravitation. [3]

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- (b) Deduce that the gravitational field strength g at the surface of a spherical planet of uniform density is given by

$$g = \frac{GM}{R^2}$$

where M is the mass of the planet, R is its radius and G is the gravitational constant. You can assume that spherical objects of uniform density act as point masses. [2]

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(Question B2, part 2 continued)

- (c) The gravitational field strength at the surface of Mars g_M is related to the gravitational field strength at the surface of the Earth g_E by

$$g_M = 0.38 \times g_E.$$

The radius of Mars R_M is related to the radius of the Earth R_E by

$$R_M = 0.53 \times R_E.$$

Determine the mass of Mars M_M in terms of the mass of the Earth M_E .

[2]

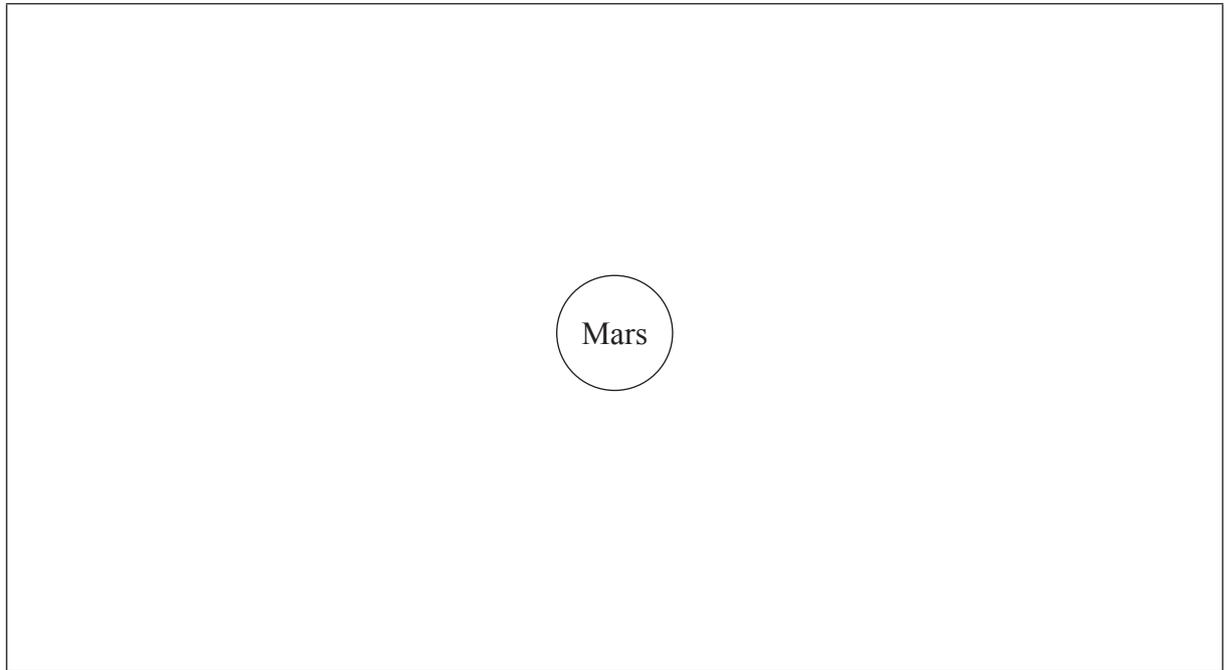
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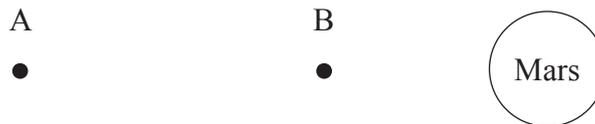


(Question B2, part 2 continued)

- (d) (i) On the diagram below, draw lines to represent the gravitational field around the planet Mars. [1]



- (ii) An object falls freely in a straight line from point A to point B in time t . The speed of the object at A is u and the speed at B is v . A student suggests using the equation $v = u + g_M t$ to calculate v . Suggest **two** reasons why it is not appropriate to use this equation. [2]



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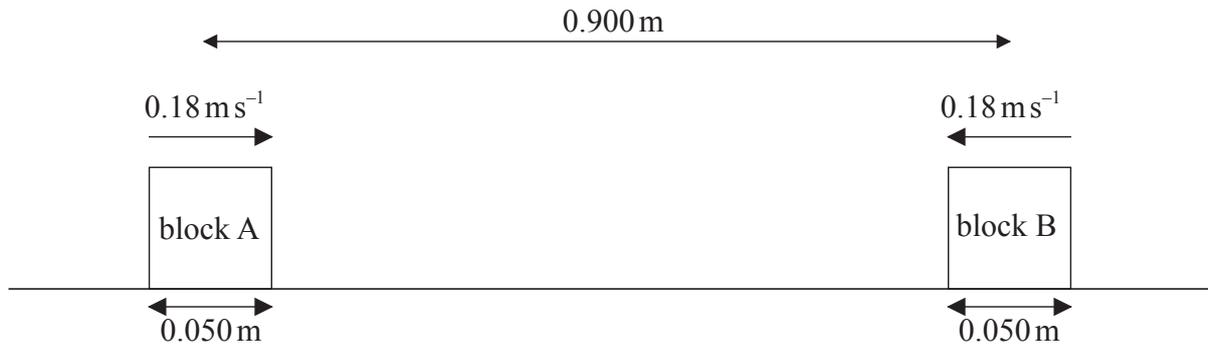
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B3. This question is in **two** parts. **Part 1** is about a collision. **Part 2** is about electric current and resistance.

Part 1 A collision

Two identical blocks of mass 0.17 kg and length 0.050 m are travelling towards each other along a straight line through their centres as shown below. Assume that the surface is frictionless.



The initial distance between the centres of the blocks is 0.900 m and both blocks are moving at a speed of 0.18 m s^{-1} relative to the surface.

(a) Determine the time taken for the blocks to come into contact with each other. [3]

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(Question B3, part 1 continued)

(b) As a result of the collision, the blocks reverse their direction of motion and travel at the same speed as each other. During the collision, 20% of the kinetic energy of the blocks is given off as thermal energy to the surroundings.

(i) State and explain whether the collision is elastic or inelastic. [2]

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(ii) Show that the final speed of the blocks relative to the surface is 0.16 m s^{-1} . [3]

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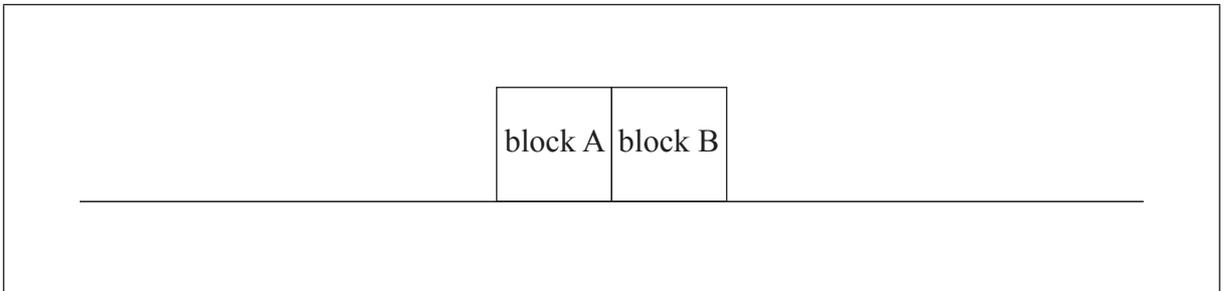


(Question B3, part 1 continued)

- (c) (i) State Newton's third law of motion. [1]

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- (ii) During the collision of the blocks, the magnitude of the force that block A exerts on block B is F_{AB} and the magnitude of the force that block B exerts on block A is F_{BA} . On the diagram below, draw labelled arrows to represent the magnitude and direction of the forces F_{AB} and F_{BA} . [3]



- (iii) The duration of the collision between the blocks is 0.070 s. Determine the average force one block exerted on the other. [3]

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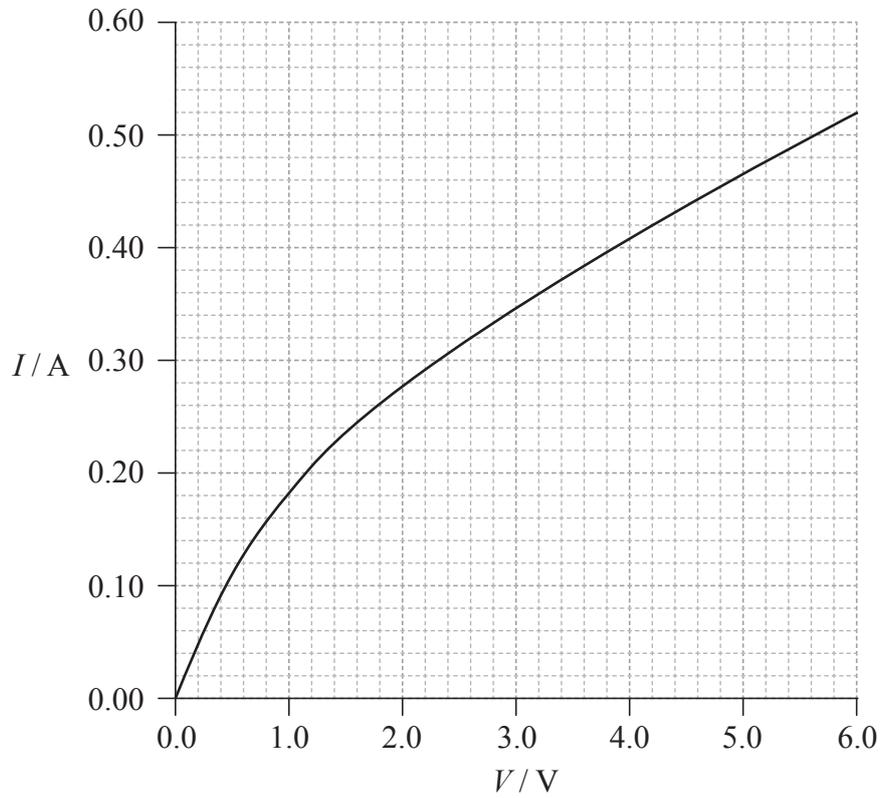
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(Question B3 continued from page 24)

Part 2 Electric current and resistance

The graph below shows how the current I in a tungsten filament lamp varies with potential difference V across the lamp.



- (a) (i) Define the electrical *resistance* of a component. [1]

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(Question B3, part 2 continued)

- (ii) Explain whether or not the filament obeys Ohm's law. [2]

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- (b) (i) Calculate the resistance of the filament lamp when the potential difference across it is 2.8 V. [2]

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- (ii) The length of the filament in a lamp is 0.40 m. The resistivity of tungsten when the potential difference across it is 2.8 V is $5.8 \times 10^{-7} \Omega\text{m}$. Calculate the radius of the filament. [3]

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(Question B3, part 2 continued)

- (c) Two identical filament lamps are connected in series with a cell of emf 6.0 V and negligible internal resistance. Using the graph on page 26, calculate the total power dissipated in the circuit. [2]

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