IB DIPLOMA PROGRAMME
PROGRAMME DU DIPLÔME DU BI
PROGRAMA DEL DIPLOMA DEL BI

M07/4/PHYSI/SP2/ENG/TZ1/XX+

22076511

PHYSICS
STANDARD LEVEL
PAPER 2

Wednesday 2 May 2007 (afternoon)

1 hour 15 minutes

Candidate session number

0	0							

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 of Section A in the spaces provided.
- Section B: answer one question from Section B in the spaces provided.
- At the end of the examination, indicate the numbers of the questions answered in the candidate box on your cover sheet.

2207-6511

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22 pages

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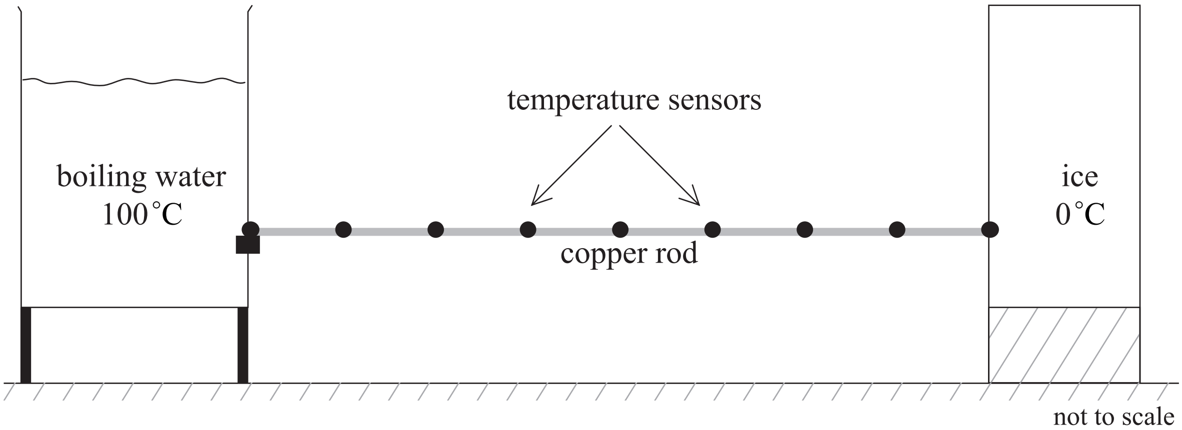
SECTION A

*Answer **all** the questions in the spaces provided.*

A1. This question is about thermal energy transfer through a rod.

A student designed an experiment to investigate the variation of temperature along a copper rod when each end is kept at a different temperature. In the experiment, one end of the rod is placed in a container of boiling water at 100 °C and the other end is placed in contact with a block of ice at 0.0 °C as shown in the diagram.



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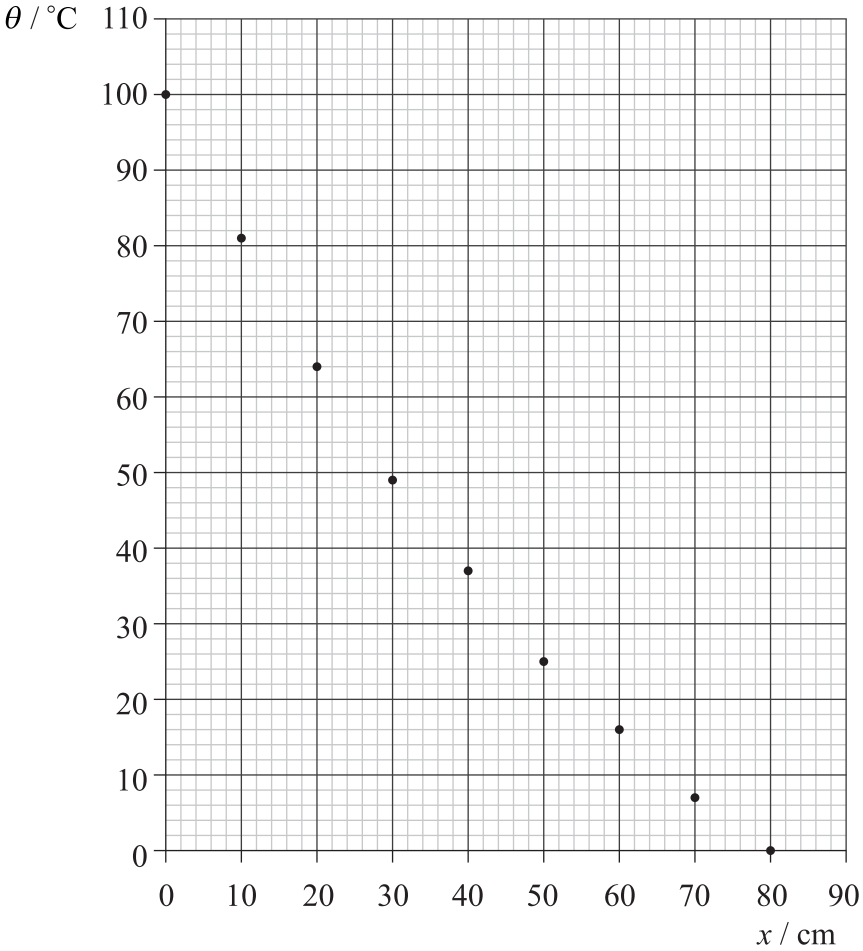
(Question A1 continued)

Temperature sensors are placed at 10 cm intervals along the rod. The final steady state temperature θ of each sensor is recorded, together with the corresponding distance x of each sensor from the hot end of the rod.

The data points are shown plotted on the axes below.



The uncertainty in the measurement of θ is $\pm 2\,^{\circ}\mathrm{C}$. The uncertainty in the measurement of x is negligible.

(a) On the graph above, draw the uncertainty in the data points for $x = 10$ cm, $x = 40$ cm and $x = 70$ cm. *[2]*

(b) On the graph above, draw the line of best-fit for the data. *[1]*

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(Question A1 continued)

(c) Explain, by reference to the uncertainties you have indicated, the shape of the line you have drawn. *[2]*

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(d) (i) Use your graph to estimate the temperature of the rod at $x = 55$ cm. *[1]*

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(ii) Determine the magnitude of the gradient of the line (the temperature gradient) at $x = 50$ cm. *[3]*

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(e) The rate of transfer of thermal energy R through the cross-sectional area of the rod is proportional to the temperature gradient $\frac{\Delta\theta}{\Delta x}$ along the rod. At $x = 10$ cm, $R = 43$ W and the magnitude of the temperature gradient is $\frac{\Delta\theta}{\Delta x} = 1.81\,^{\circ}\text{C cm}^{-1}$. At $x = 50$ cm the value of R is 25 W.

Use these data and your answer to d(ii) to suggest whether the rate R of thermal energy transfer is in fact proportional to the temperature gradient. *[3]*

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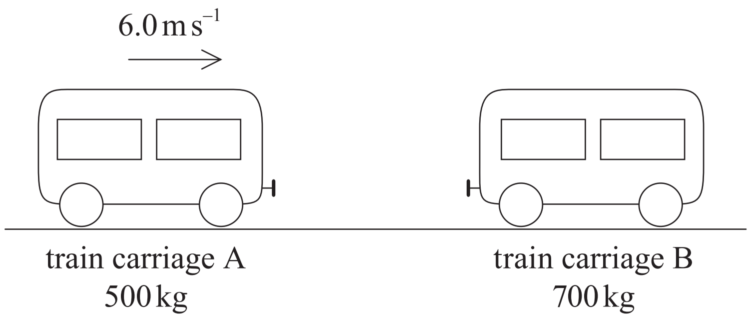
A2. This question is about energy and momentum.

A train carriage A of mass 500 kg is moving horizontally at 6.0 m s^{-1}. It collides with another train carriage B of mass 700 kg that is initially at rest, as shown in the diagram below.



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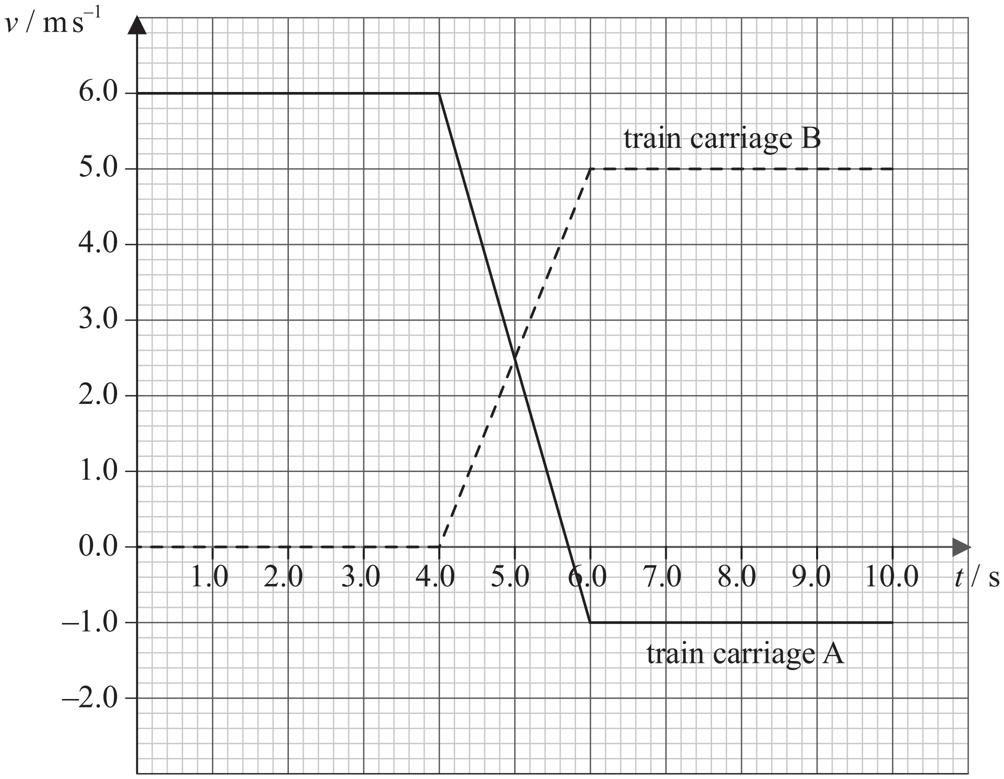
(Question A2 continued)

The graph below shows the variation with time t of the velocities of the two train carriages before, during and after the collision.



(a) Use the graph to deduce that

(i) the total momentum of the system is conserved in the collision. *[2]*

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(ii) the collision is elastic. *[2]*

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(b) Calculate the magnitude of the average force experienced by train carriage B. *[3]*

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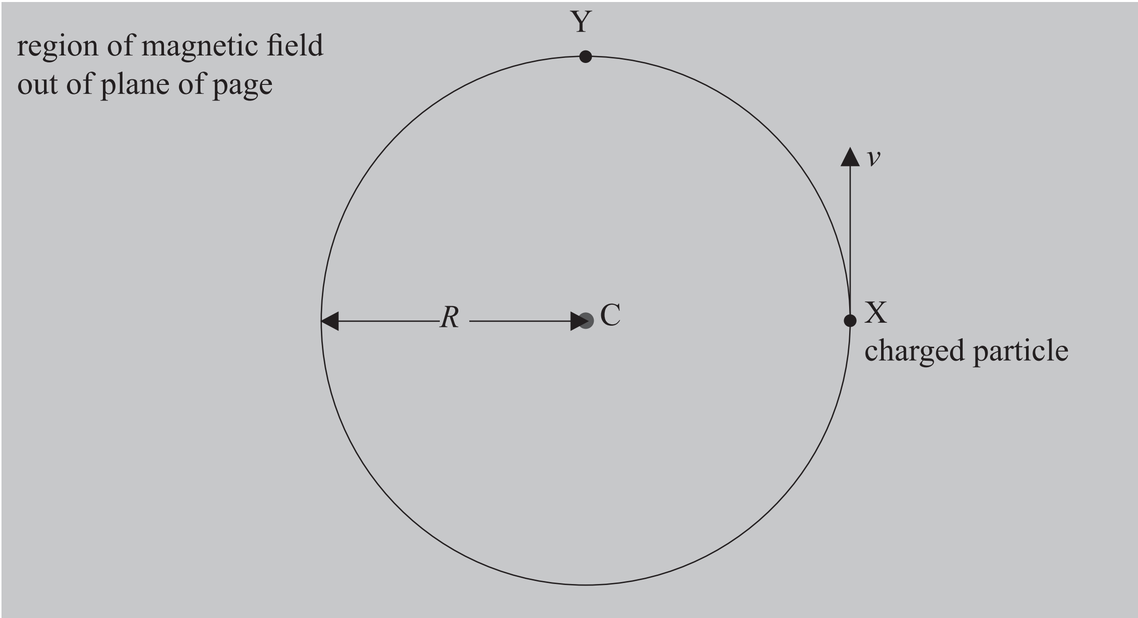
A3. This question is about motion of a charged particle in a magnetic field.

A charged particle is projected from point X with speed v at right angles to a uniform magnetic field. The magnetic field is directed out of the plane of the page. The particle moves along a circle of radius R and centre C as shown in the diagram below.



(a) On the diagram above, draw arrows to represent the magnetic force on the particle at position X and at position Y. *[1]*

(b) State and explain whether

(i) the charge is positive **or** negative. *[1]*

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(ii) work is done by the magnetic force. *[2]*

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(c) A second identical charged particle is projected at position X with a speed $\frac{v}{2}$ in a direction opposite to that of the first particle. On the diagram above, draw the path followed by this particle. *[2]*

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SECTION B

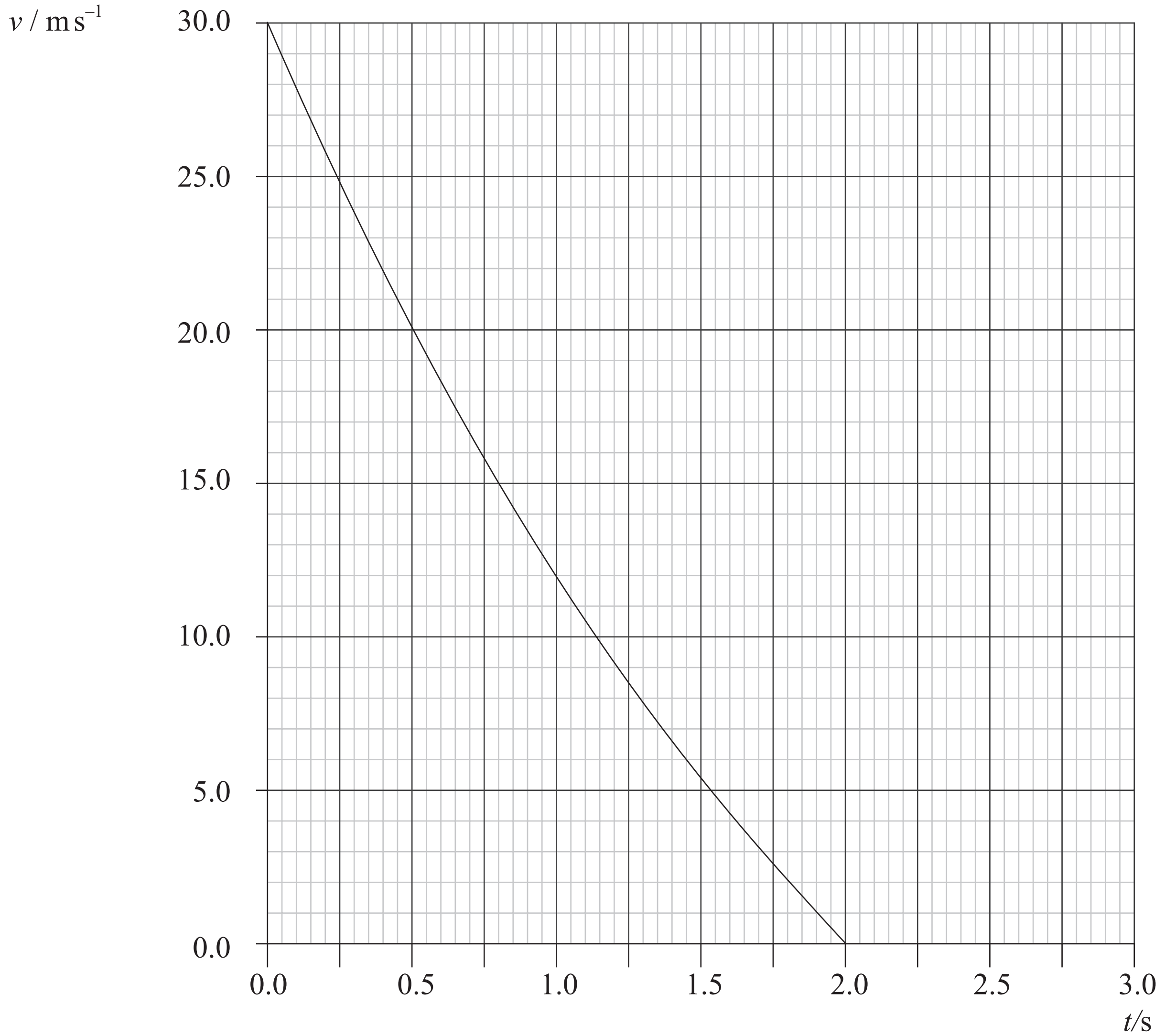
This section consists of three questions: B1, B2 and B3. Answer ***one*** *question.*

B1. This question is in **two** parts. **Part 1** is about the motion of a ball in the presence of air resistance. **Part 2** is about nuclear decay.

Part 1 Motion of a ball

A ball of mass 0.25 kg is projected vertically upwards from the ground with an initial velocity of 30 m s^{-1}. The acceleration of free fall is 10 m s^{-2}, but air resistance **cannot** be neglected.

The graph below shows the variation with time t of the velocity v of this ball for the upward part of the motion.



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(Question B1, part 1 continued)

(a) State what the area under the graph represents. *[1]*

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(b) Estimate the maximum height reached by the ball. *[1]*

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(c) Determine, for the ball at $t = 1.0\text{s}$,

(i) the acceleration. *[3]*

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(ii) the magnitude of the force of air resistance. *[2]*

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(d) Use the graph to explain, without any further calculations, that the force of air resistance is decreasing in magnitude as the ball moves upward. *[2]*

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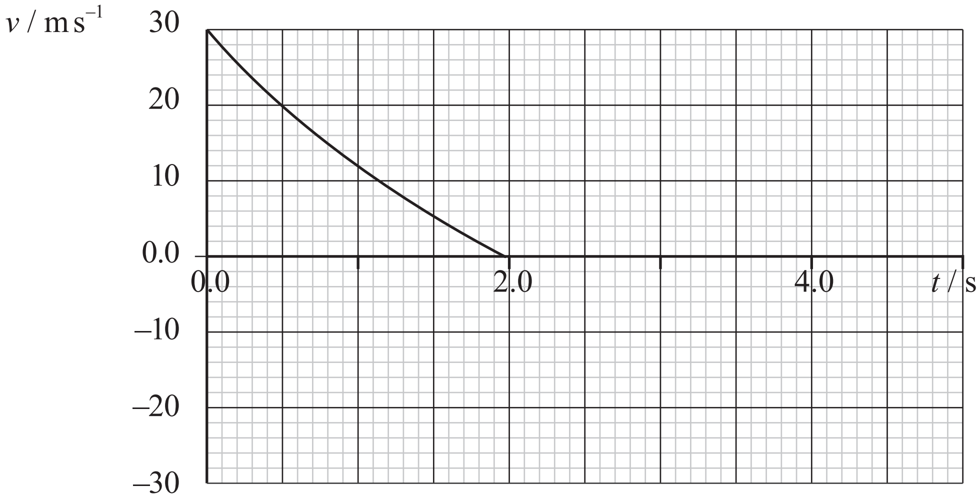
(This question continues on the following page)

(Question B1, part 1 continued)

(e) The diagram below is a sketch graph of the upward motion of the ball.

Draw a line to indicate the downward motion of the ball. The line should indicate the motion from the maximum height of the ball until just before it hits the ground. *[2]*



(f) State and explain, by reference to energy transformations, whether the speed with which the ball hits the ground is equal to 30 m s^{-1}. *[2]*

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(g) Use your answer in (f) to state and explain whether the ball takes 2.0 s to move from its maximum height to the ground. *[2]*

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(This question continues on the following page)

(Question B1, continued)

Part 2 Nuclear decay

(a) State the nature of an α-particle. *[1]*

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(b) In the Rutherford-Geiger-Marsden experiment to investigate the structure of the atom, α-particles were directed towards a gold foil. Explain why α-particles, rather than electrons, were used in this experiment. *[2]*

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(c) Uranium-238 $\left({}^{238}_{92}\text{U}\right)$ undergoes α-decay to form thorium (Th). The half-life of uranium ${}^{238}_{92}\text{U}$ is 4.5×10^{9} years.

(i) Define *half-life*. *[2]*

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(ii) Write down the nuclear equation for the α-decay of uranium to thorium. *[2]*

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(d) Thorium is radioactive and further decays occur, eventually giving lead which is stable. These further decays all occur within a time that is short compared to the half-life of ${}^{238}_{92}\text{U}$. In a sample of rocks the ratio of the number of uranium atoms to the number of lead atoms is $\frac{1}{7}$.

(i) Estimate the age of the rocks assuming that no lead was initially present in the rocks. *[2]*

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(ii) State **one** further assumption that is made in this estimate. *[1]*

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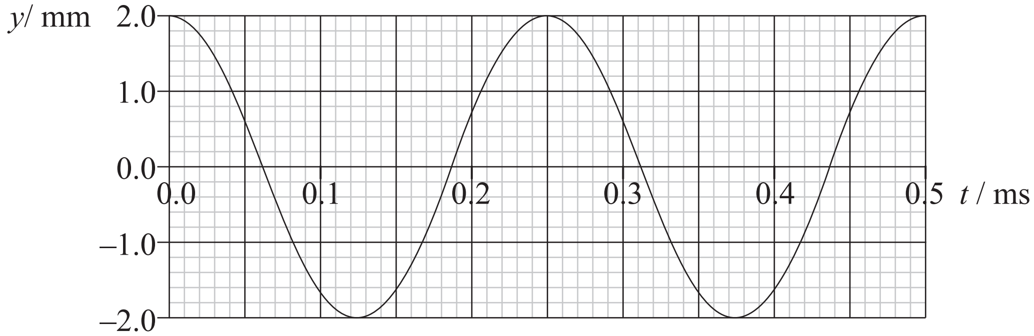
B2. This question is in **two** parts. **Part 1** is about waves on a string and interference. **Part 2** is about specific latent heat.

Part 1 Waves on a string

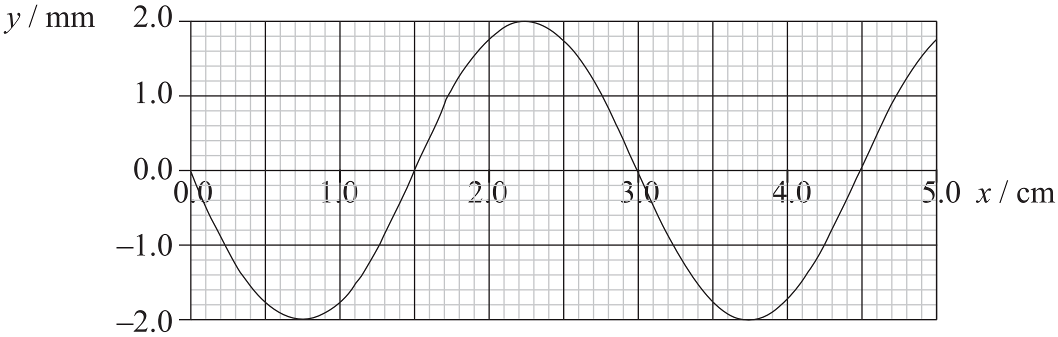
A travelling wave is created on a string. The graph below shows the variation with time t of the displacement y of a particular point on the string.

Graph 1



The variation with distance x of the displacement y of the string at $t = 0$ is shown below.

Graph 2



(a) Use information from the graphs to calculate, for this wave,

(i) the wavelength. *[1]*

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(ii) the frequency. *[2]*

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(iii) the speed of the wave. *[1]*

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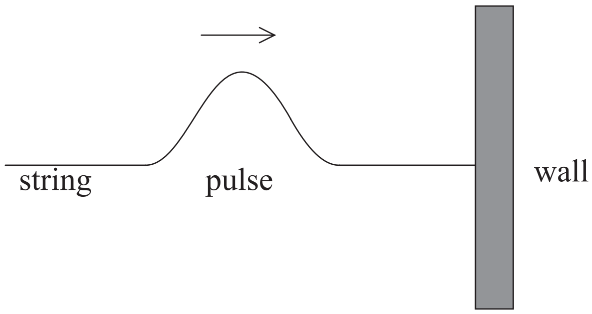
(Question B2, part 1 continued)

(b) The wave is moving from left to right and has period T.

(i) On **graph 1**, draw a labelled line to indicate the amplitude of the wave. *[1]*

(ii) On **graph 2**, draw the displacement of the string at $t = \frac{T}{4}$. *[2]*

(c) One end of the string is attached to a wall. A student creates a single pulse in the string that travels to the right as shown in the diagram below.



(i) In the space below, draw a diagram to show the shape and size of the pulse after it has been reflected from the wall. *[2]*

(ii) By reference to Newton's third law, explain the nature of the reflected pulse that you have drawn in (c)(i) above. *[2]*

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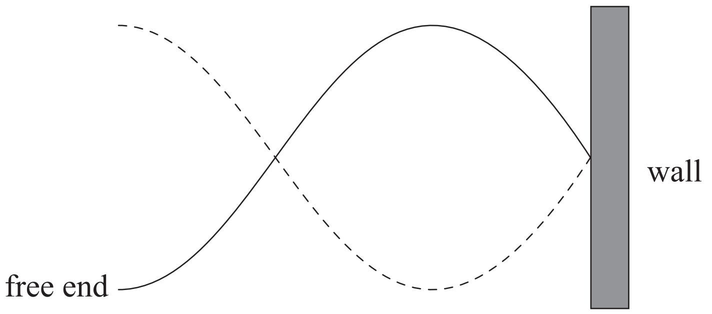
(Question B2, part 1 continued)

(d) The free end of the string in (c) is now made to oscillate with frequency f such that a standing wave is established on the string. The diagram below illustrates the standing wave.



(i) Explain, by reference to the principle of superposition, the formation of a standing wave. *[3]*

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(ii) The length of the string is 3.0 m. Using your answer for the speed of the wave in (a)(iii) calculate the frequency f. *[2]*

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(Question B2 continued)

Part 2 Specific latent heat

(a) Define *specific latent heat of fusion*. *[1]*

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(b) Solar radiation is incident on a pond of area $12\,m^2$. The pond is covered by a layer of ice of thickness 3.0 cm. The temperature of the ice is 0.0 °C.

(i) The density of ice is $900\,kg\,m^{-3}$. Deduce that the mass of ice on the pond is approximately 320 kg. *[2]*

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(ii) The average power per unit area incident on the ice over a period of 6.0 hours is $340\,W\,m^{-2}$. Deduce that the energy incident on the pond in this time is 8.8×10^{7} J. *[1]*

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(iii) The specific latent heat of fusion of ice is $330\,kJ\,kg^{-1}$. Determine whether all the ice on the pond will melt in the 6.0 hour time period. *[2]*

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(iv) State **one** assumption you made in reaching your answer to (b)(iii). *[1]*

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(c) During the night, the air temperature drops to –5 °C. The ice that melted during the day freezes again. Outline **one** mechanism by which thermal energy is lost by the ice. *[2]*

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B3. This question is in **two** parts. **Part 1** is about electrical conduction and **Part 2** is about a block on an inclined plane.

Part 1 Electrical conduction

In a copper wire the number of conduction electrons is equal to the number of copper atoms in the wire.

(a) State what is meant by *conduction electrons*. *[1]*

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(b) (i) The density of copper is $8.93 \times 10^3\ \text{kg m}^{-3}$ and its molar mass is 64 g. Deduce that the number of moles of copper in a volume of $1.0\ \text{m}^3$ is 1.4×10^5. *[2]*

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(ii) Estimate the number of conduction electrons in $1.0\ \text{m}^3$ of copper. *[1]*

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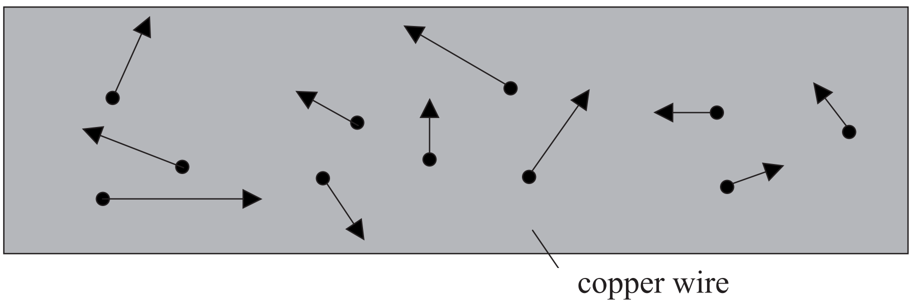
(c) The diagram below shows some of the conduction electrons in a copper wire. The arrows represent the random velocities of the electrons.



Explain, by reference to the motion of the electrons, why there is no current in the wire. *[2]*

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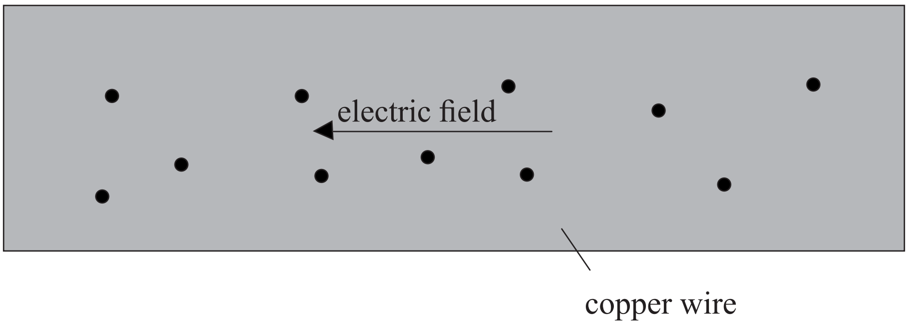
(Question B3, part 1 continued)

(d) An electric field is established inside the copper wire directed as shown in the diagram below. The dots represent electrons. The random velocities of the electrons are not shown.

On the diagram below, draw an arrow to indicate the direction of the drift velocity of the electrons. *[1]*



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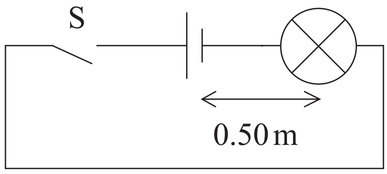
(Question B3, part 1 continued)

(e) A typical value for the electron drift velocity in a copper wire is $10^{-3}\,\text{m}\,\text{s}^{-1}$. In the circuit below, the length of the copper wire joining the negative terminal of the battery to the lamp is 0.50 m.



(i) The switch S is closed. Calculate the time it would take for an electron to move from the negative terminal of the battery to the lamp. *[1]*

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(ii) The lamp lights in a time much less than that calculated in (e)(i). Explain this observation. *[2]*

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(iii) Discuss, in terms of the movement of the electrons, the energy transformations taking place in the filament of the lamp. *[4]*

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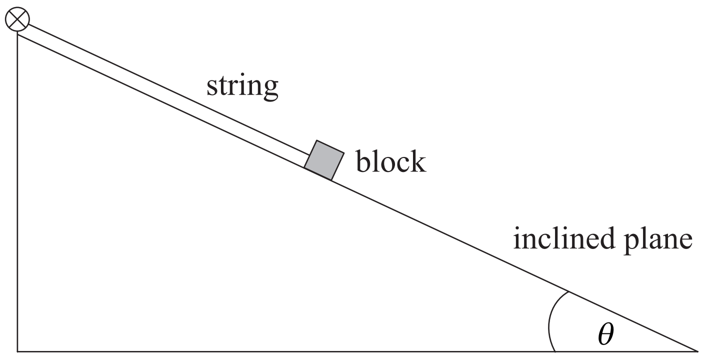
(Question B3 continued)

Part 2 Block on an inclined plane

A block is held stationary on a frictionless inclined plane by means of a string as shown below.



(a) (i) On the diagram draw arrows to represent the three forces acting on the block. *[3]*

(ii) The angle θ of inclination of the plane is 25°. The block has mass 2.6 kg. Calculate the force in the string. You may assume that $g = 9.8\,\text{m s}^{-2}$. *[2]*

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(This question continues on the following page)

(Question B3, part 2 continued)

(b) The string is pulled so that the block is now moving at a constant speed of $0.85\,\text{m}\,\text{s}^{-1}$ up the inclined plane.

(i) Explain why the magnitude of the force in the string is the same as that found in (a)(ii). *[2]*

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(ii) Calculate the power required to move the block at this speed. *[2]*

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(iii) State the rate of change of the gravitational potential energy of the block. Explain your answer. *[2]*

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