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

M06/4/PHYSI/SP2/ENG/TZ1/XX+

22066511

PHYSICS
STANDARD LEVEL
PAPER 2

Tuesday 9 May 2006 (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.

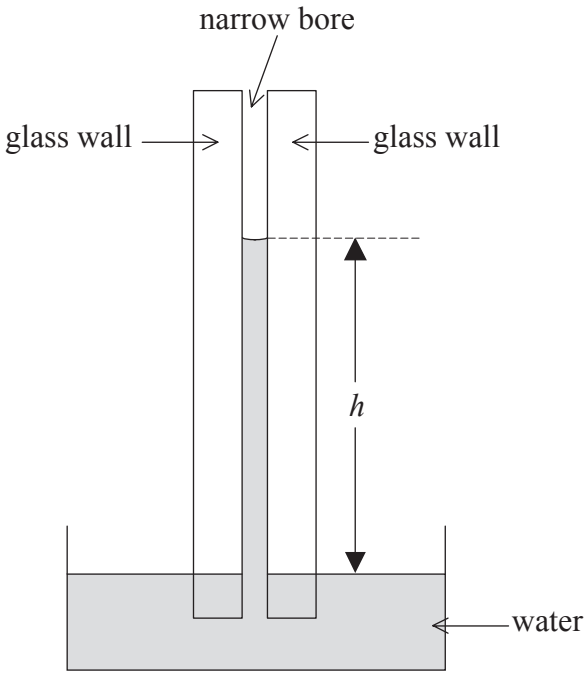
0123

SECTION A

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

A1. This question is about the rise of water in a capillary tube.

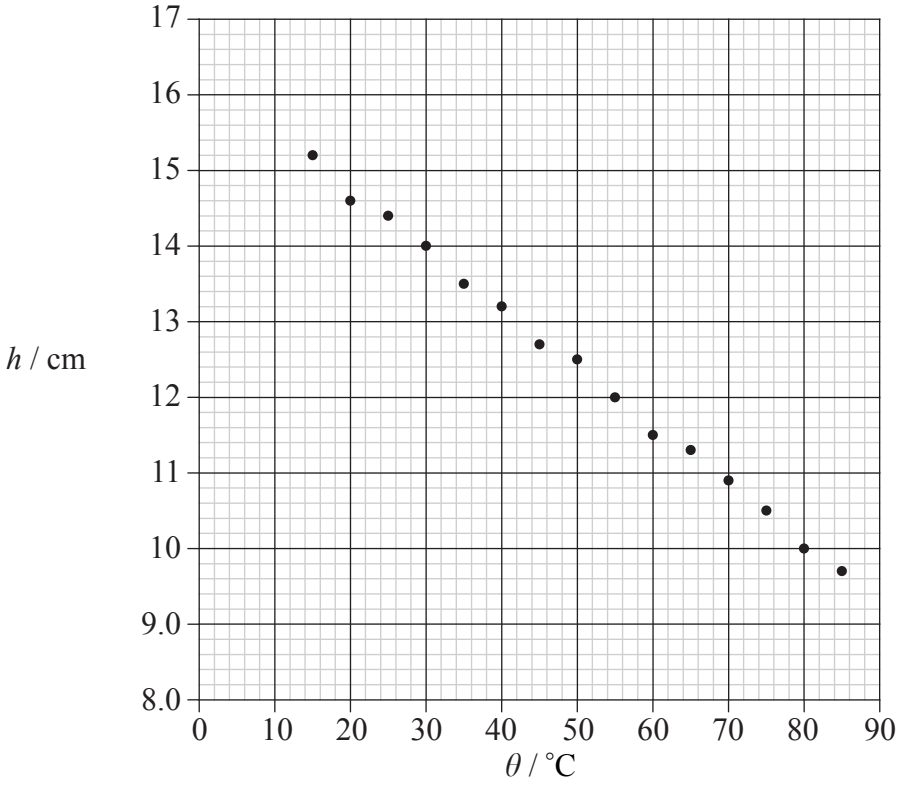
A capillary tube is a tube that is open at both ends and has a very narrow bore. A capillary tube is supported vertically with one end immersed in water. Water rises up the tube due to a phenomenon called capillary action. The water in the bore of the tube forms a column of height *h* as shown below.



(This question continues on the following page)

(Question A1 continued)

(a) The height h, for a particular capillary tube was measured for different temperatures of the water. The variation with temperature θ of the height h is shown below. Uncertainties in the measurements are not shown.



(i) On the graph above, draw a best-fit line for the data points. *[1]*

(ii) Determine the height h_0 of the water column at temperature $\theta = 0°C$. *[1]*

. . . . . .

. . . . . .

(This question continues on the following page)

(Question A1 continued)

(b) Explain why the results of this experiment suggest that the relationship between the height h and temperature θ is of the form

$$h = h_0(1 - k\theta)$$

where k is constant. *[4]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(c) Deduce that the value of k is approximately 4.8×10^{-3} deg C^{-1}. *[3]*

. . . . . .

. . . . . .

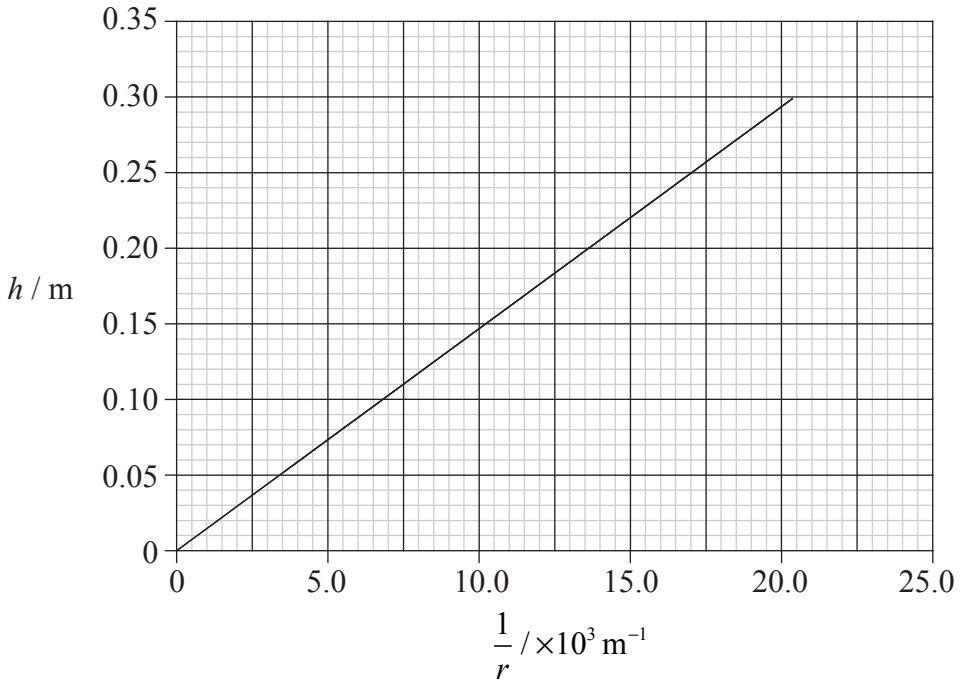
. . . . . .

. . . . . .

(This question continues on the following page)

(Question A1 continued)

(d) The experiment is repeated using tubes with bores of different radii r but keeping the water temperature constant. The graph below shows the variation with $\frac{1}{r}$ of the height h for capillary tubes of different radii r for a water temperature of 20°C.



It is suggested that capillary action is one of the means by which water moves from the roots of a tree to the leaves. A particular tree has a height of 25 m.

Use the graph to estimate the radius of the bore of the tubes that would enable water to be raised by capillary action from ground level to the top of the tree. Comment on your answer. *[4]*

Estimate: . . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

Comment: . . . . . .

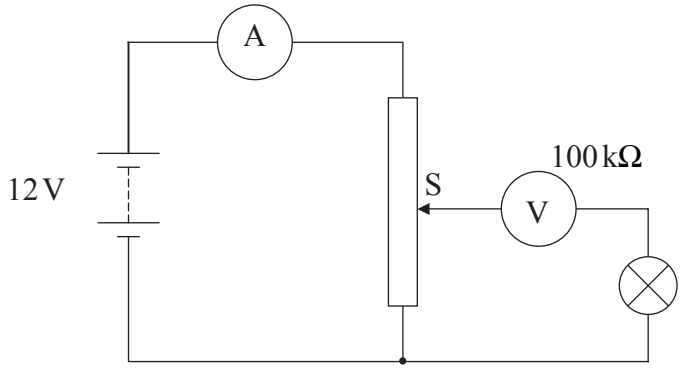
. . . . . .

. . . . . .

A2. This question is about an electric circuit

A particular filament lamp is rated at 12 V, 6.0 mA. It just lights when the potential difference across the filament is 6.0 V.
A student sets up an electric circuit to measure the *I-V* characteristics of the filament lamp.

In the circuit, shown below, the student has connected the voltmeter and the ammeter into the circuit **incorrectly**.



The battery has e.m.f. 12 V and negligible internal resistance. The ammeter has negligible resistance and the resistance of the voltmeter is 100 kΩ.

The maximum resistance of the variable resistor is 15 Ω.

(a) Explain, without doing any calculations, whether there is a position of the slider S at which the lamp will be lit. *[3]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) Estimate the maximum reading of the ammeter. *[2]*

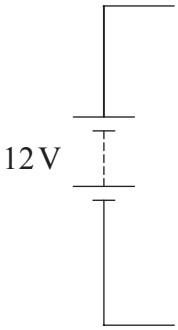
. . . . . .

. . . . . .

(This question continues on the following page)

(Question A2 continued)

(c) Complete the circuit diagram below showing the correct position of the voltmeter and of the ammeter in order to determine the *I*-*V* characteristics of the filament lamp. *[2]*

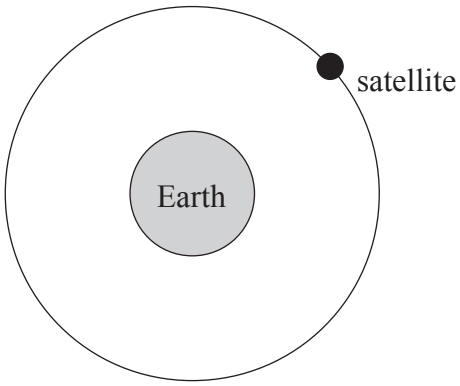


A3. This question is about circular motion.

A geo-stationary satellite is one that orbits the Earth in an equatorial plane in the same direction of rotation as that of the Earth and with an orbital period of 24 hours. Since the period of rotation of the Earth is 24 hours, this means that the satellite is stationary relative to a point on the Equator.

(a) The diagram below shows a geostationary satellite in orbit about the Earth.

not to scale



On the diagram above, draw an arrow to show the direction of acceleration of the satellite. *[1]*

(b) State the name of the force causing the satellite's acceleration. *[1]*

. . . . . .

(c) The distance of the satellite from the centre of the Earth is 4.2×10^7 m. Calculate the acceleration of the satellite. *[3]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

SECTION B

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

B1. This question is about specific heat capacity and a domestic shower.

(a) Define the term *specific heat capacity*. *[1]*

. . . . . .

. . . . . .

. . . . . .

(b) Equal masses of two different solid substances A and B are at the same temperature. The specific heat capacity of substance A is greater than the specific heat capacity of substance B. The two substances now have their temperatures raised by the same amount.

Explain which substance will have the greater increase in internal energy assuming both remain in the solid phase. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(This question continues on the following page)

(Question B1 continued)

(c) In an experiment to measure the specific heat capacity of a metal, a piece of the metal is immersed in boiling water and left there for several minutes. It is then transferred quickly into some cold water in a calorimeter. The water is stirred and the maximum temperature of the water is recorded.

(i) State why the metal is left in the boiling water for several minutes. *[1]*

. . . . . .

. . . . . .

(ii) Write down a word equation for the thermal energy Q_M lost by the metal to the water. *[1]*

. . . . . .

. . . . . .

(iii) Write down a word equation for the thermal energy Q_W gained by the water in the calorimeter. *[1]*

. . . . . .

. . . . . .

(iv) A value of the specific heat capacity of the metal may be calculated from (ii) and (iii) by assuming that $Q_M = Q_W$.

State why in practice, this assumption leads to an error in the calculated value of the specific heat capacity. *[1]*

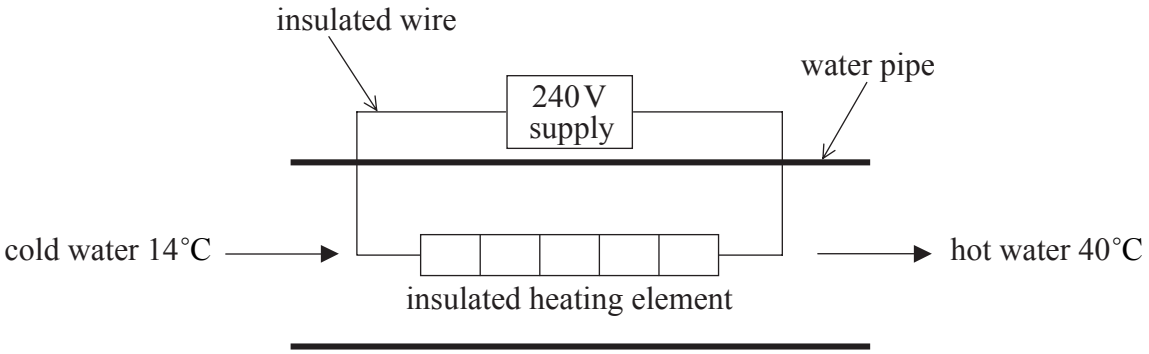
. . . . . .

. . . . . .

(This question continues on the following page)

(Question B1 continued)

(d) The diagram below shows part of the heating circuit of a domestic shower.



Cold water enters the shower unit and flows over an insulated heating element. The heating element is rated at 7.2 kW, 240 V. The water enters at a temperature of 14°C and leaves at a temperature of 40°C. The specific heat capacity of water is $4.2 \times 10^3\,\text{J kg}^{-1}\,\text{K}^{-1}$.

(i) Describe how thermal energy is transferred from the heating element to the water. *[3]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(ii) Estimate the flow rate in kg s^{-1} of the water. *[4]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(This question continues on the following page)

(Question B1 continued)

(iii) Suggest **two** reasons why your answer to (b) is only an estimate. *[2]*

1. . . . . .

. . . . . .

2. . . . . .

. . . . . .

(iv) Calculate the current in the heating element when the element is operating at 7.2 kW. *[2]*

. . . . . .

. . . . . .

. . . . . .

(v) Explain why, when the shower unit is switched on, the initial current in the heating element is greater than the current calculated in (iv). *[2]*

. . . . . .

. . . . . .

. . . . . .

(This question continues on the following page)

(Question B1 continued)

(e) In some countries, shower units are operated from a 110 V supply. A heating element operating with a 240 V supply has resistance R_{240} and an element operating from a 110 V supply has resistance R_{110}.

(i) Deduce, that for heating elements to have identical power outputs

$$\frac{R_{110}}{R_{240}} = 0.21.$$ *[3]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(ii) Using the ratio in (i), describe and explain **one** disadvantage of using a 110 V supply for domestic purposes. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

B2. This question is in **two** parts. **Part 1** is about momentum. **Part 2** is about radioactive decay.

Part 1 Momentum

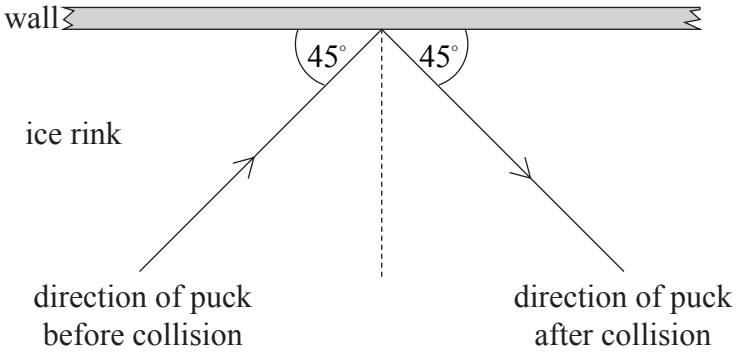
(a) State the law of conservation of momentum. *[2]*

. . . . . .

. . . . . .

. . . . . .

(b) An ice hockey puck collides with the wall of an ice rink. The puck is sliding along a line that makes an angle of 45° to the wall.



The collision between the wall and the puck is perfectly elastic.

(i) State what is meant by an *elastic collision*. *[1]*

. . . . . .

. . . . . .

(ii) Discuss how the law of conservation of momentum applies to this situation. *[2]*

. . . . . .

. . . . . .

. . . . . .

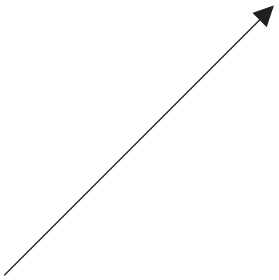
. . . . . .

(This question continues on the following page)

(Question B2, part 1 continued)

(c) The diagram below is a scale diagram that shows the vector representing the momentum of the puck before collision.

Scale: 1.0 cm = 0.10 N s

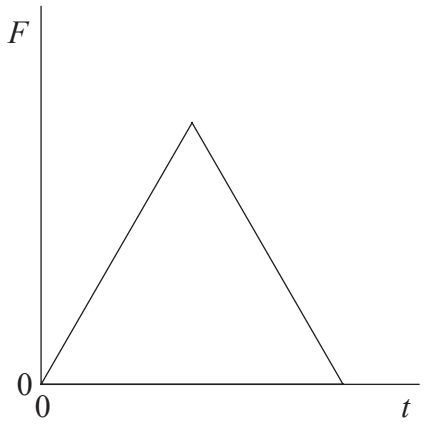


By adding appropriate vectors to the diagram, deduce that the magnitude of the change in momentum of the puck as a result of the collision is 0.71 N s. *[4]*

(This question continues on the following page)

(Question B2, part 1 continued)

(d) The sketch-graph below shows the variation with time t of the force F exerted by the wall on the puck.



The total contact time is 12 ms. Estimate, explaining your reasoning, the maximum force exerted by the wall on the puck. *[3]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(This question continues on the following page)

(Question B2 continued)

Part 2 Radioactive decay

(a) Carbon-14 is a radioactive isotope with a half-life of 5500 years. It is produced in the atmosphere by neutron bombardment of nitrogen. The equation for this reaction is

$$^{14}_{7}\mathrm{N} + ^{1}_{0}\mathrm{n} \rightarrow ^{14}_{6}\mathrm{C} + \mathrm{X}.$$

(i) Explain what are meant by *isotopes*. *[1]*

. . . . . .

. . . . . .

(ii) Define the term *radioactive half-life*. *[1]*

. . . . . .

. . . . . .

(iii) Identify the particle X. *[1]*

. . . . . .

(b) Living trees contain atoms of carbon-14. The activity per gram of carbon from a living tree is higher than that per gram of carbon-14 from burnt wood (charcoal) found at an ancient campsite.

(i) A living tree continuously takes in carbon dioxide from the atmosphere. Suggest why the activity of the carbon from the charcoal is less than that of the living wood. *[3]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(ii) Each gram of a living tree contains approximately 1×10^{-12} g of the isotope carbon-14. Deduce that each gram of carbon in living wood contains approximately 4×10^{10} atoms of carbon-14. *[2]*

. . . . . .

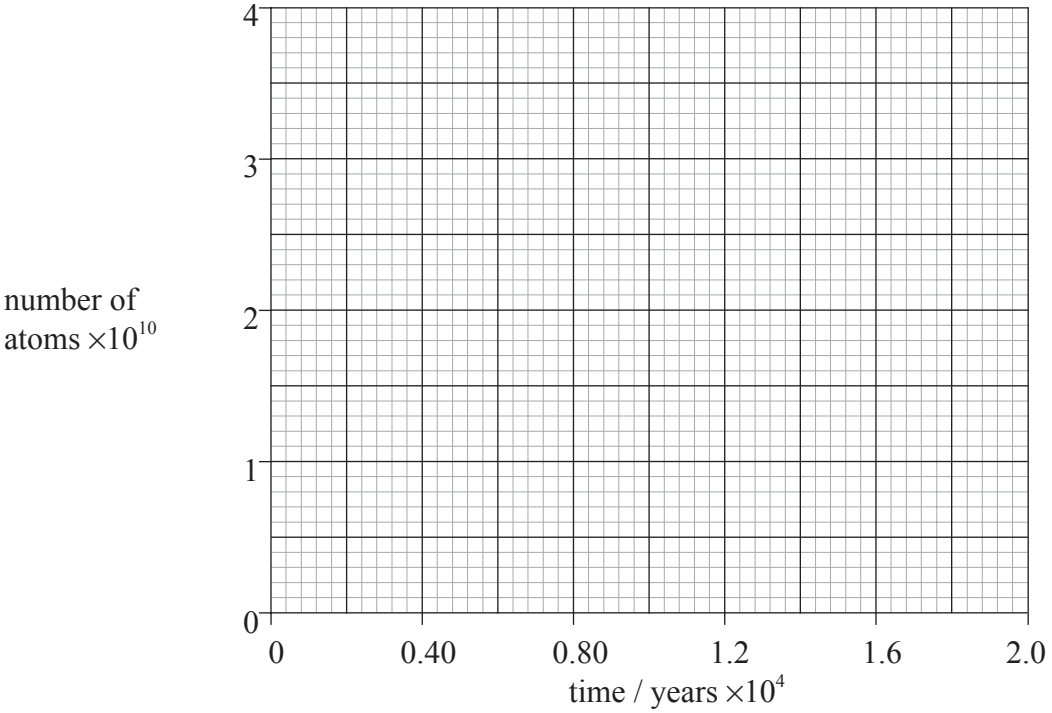
. . . . . .

. . . . . .

(This question continues on the following page)

(Question B2, part 2 continued)

(c) On the grid below, draw a graph to show the variation with time of the number of carbon-14 atoms in one gram of wood from a tree. Your graph should indicate the number of atoms for a period of 1.8×10^4 years after the tree has died. (Half-life of carbon-14 = 5500 years) *[3]*



(d) The activity of a radioactive sample is proportional to the number of atoms in the sample. The activity per gram of carbon from a living tree is 9.6 disintegrations per minute. The activity per gram of carbon in burnt wood found at the ancient campsite is 1.9 disintegrations per minute.

(i) Estimate the number of atoms of carbon-14 in the burnt wood. *[1]*

. . . . . .

. . . . . .

(ii) From the graph you have drawn in (c), estimate the age of the burnt wood. *[1]*

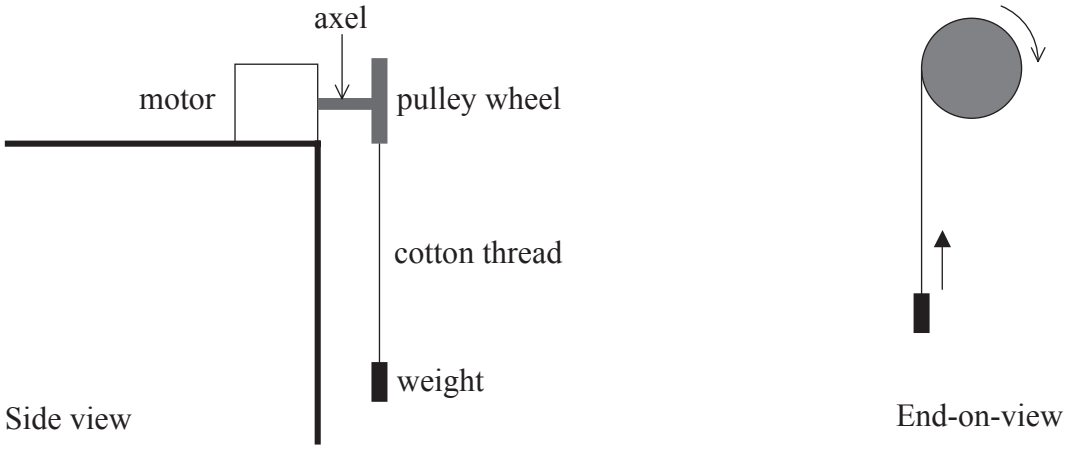
. . . . . .

Blank page

B3. This question is in **two** parts. **Part 1** is about an experiment to measure the efficiency of an electric motor. **Part 2** is about waves.

Part 1 Electric motor

(a) In an experiment to measure the efficiency of a small dc electric motor, the motor is clamped to the edge of a bench. The motor is used to raise a small weight that is attached to a pulley wheel by cotton thread. The pulley wheel is rotated by the motor. The thread wraps around the pulley wheel, so raising the weight.



The time taken for the motor to raise the weight through a certain height is measured. It is assumed that the weight accelerates uniformly whilst being raised. The weight of the cotton thread is negligible.

(i) Draw a labelled free-body force diagram of the forces acting on the accelerating weight. *[3]*

. . . . . .

. . . . . .

. . . . . .

(This question continues on the following page)

(Question B3, part 1 continued)

(ii) The weight has a mass of 15 g and it takes 2.2 s to raise it from rest through a height of 0.84 m. Calculate the tension in the thread as the weight is being raised. (Acceleration of free fall $g = 10\,\text{m s}^{-2}$.) *[4]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) In a second experiment, the current is adjusted so that the weight of mass 15 g is raised at constant speed. The motor is connected to a 6.0 V supply and it now takes the motor 3.4 s to raise the weight through 0.84 m.

(i) Suggest how it might be determined that the weight is being raised at constant speed. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(ii) Determine the power delivered to the weight by the motor. (Acceleration of free fall $g = 10\,\text{m s}^{-2}$.) *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(iii) The current in the motor is 45 mA. Estimate the efficiency of the motor. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(This question continues on the following page)

(Question B3 continued)

Part 2 Waves

(a) Distinguish, in terms of the propagation of energy, the difference between a *transverse* travelling wave and a *longitudinal* travelling wave. *[3]*

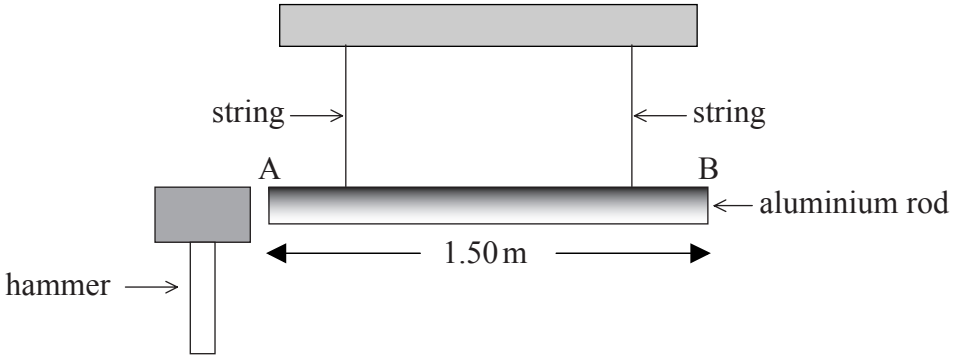
. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) The diagram below shows an aluminium rod AB of length 1.50 m hanging horizontally from two strings.



End A of the rod is hit gently with a hammer. As a result, a wave pulse travels down the rod and is reflected from end B. The hammer remains in contact with the rod until the pulse reflected from end B reaches A. This pulse causes the hammer to rebound from the end of the rod.

(i) Suggest, giving a reason, whether the wave pulse is longitudinal or transverse. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(ii) The hammer is in contact with end A of the rod for 6.00×10^{-4} s. Calculate the speed of the pulse in the rod. *[2]*

. . . . . .

. . . . . .

. . . . . .

(This question continues on the following page)

(Question B3, part 2 continued)

(iii) As a result of the rod being hit with the hammer, a sound is heard. Suggest how this sound arises. *[3]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(iv) Determine the frequency of the fundamental (first harmonic) vibration of the rod. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .