N08/4/PHYSI/SP2/ENG/TZ0/XX+

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PHYSICS
STANDARD LEVEL
PAPER 2

Tuesday 4 November 2008 (afternoon)

1 hour 15 minutes

Candidate session number

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INSTRUCTIONS TO CANDIDATES

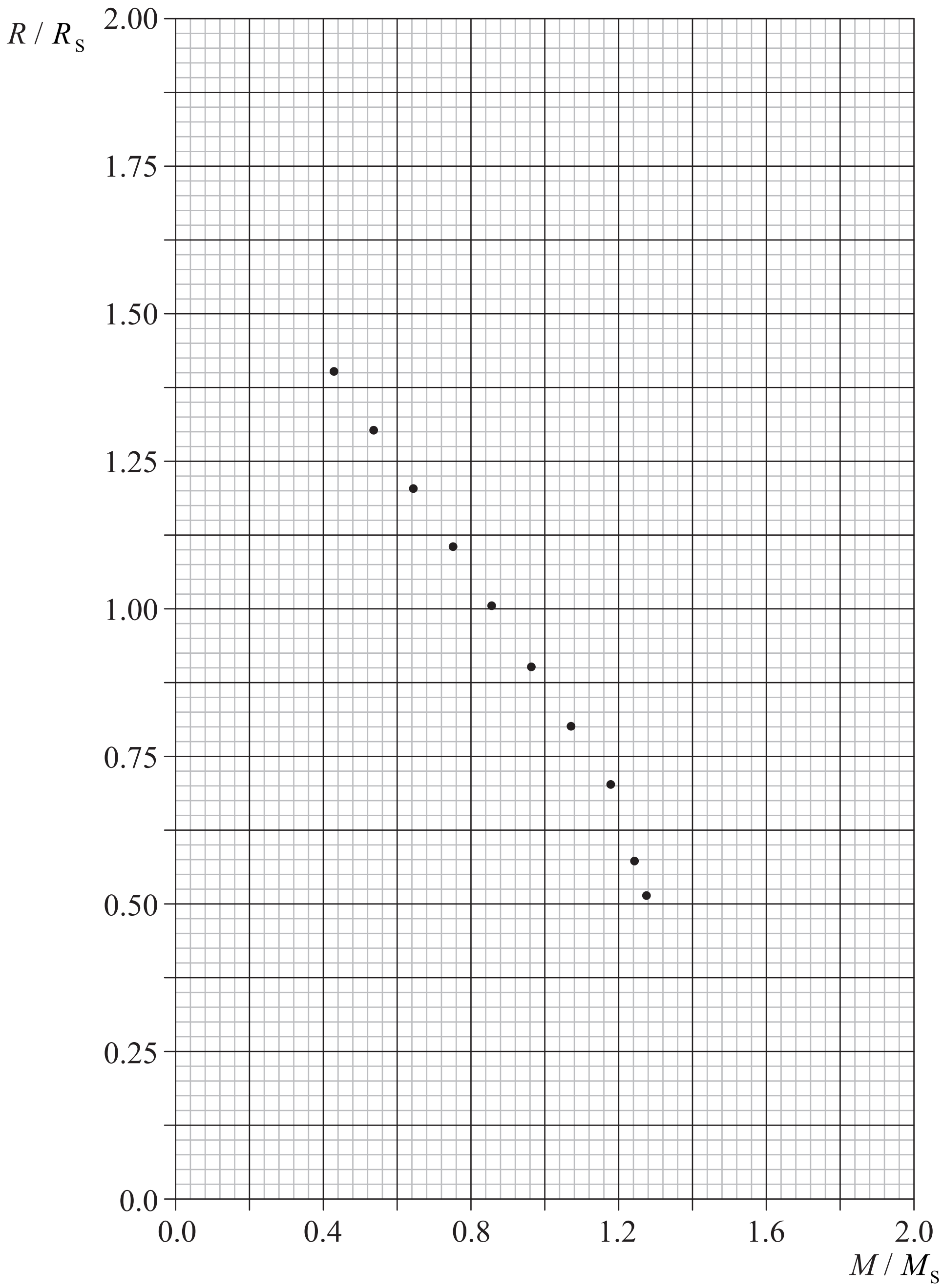
- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Section A: answer all of Section A in the spaces provided.
- Section B: answer one question from Section B in the spaces provided.
- At the end of the examination, indicate the numbers of the questions answered in the candidate box on your cover sheet.

SECTION A

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

A1. This question is about the mass-radius relation for a certain type of star.

The radius R and mass M of ten different stars were measured and the results are shown plotted below.



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(Question A1 continued)

The radius is expressed in terms of the Sun's radius R_S and the mass in terms of the Sun's mass M_S.

The uncertainty in the measurement of the mass is negligible. The uncertainty in the measurement of the radius is $\pm 0.05\,R_S$.

(a) Draw error bars for the first and the last data points. *[1]*

(b) Using your answer to (a),

(i) suggest why there might be a linear relationship between R and M for these stars. *[2]*

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(ii) determine the equation for this linear relationship. *[3]*

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(iii) estimate the maximum value for the mass of this type of star. *[1]*

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(c) Suggest why no star of this type can in fact have a mass equal to your answer to (b)(iii). *[1]*

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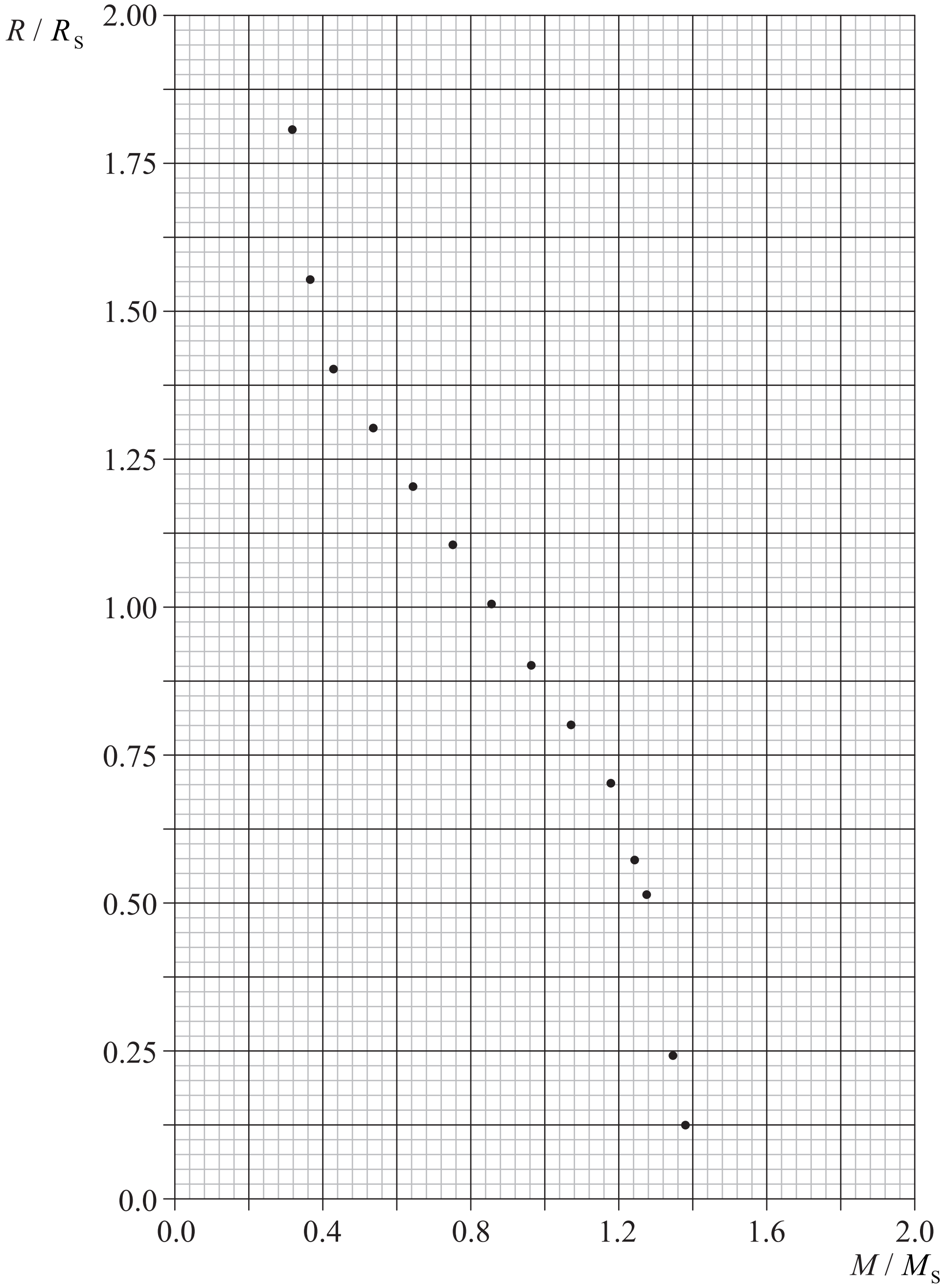
(Question A1 continued)

(d) Additional data show that the relation between R and M is in fact not linear, as suggested by the graph below.



Uncertainties in the data are not shown.

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(Question A1 continued)

(i) Draw a line of best-fit for the data. *[1]*

(ii) The new data suggests that the maximum value for the mass of this type of star is different from your answer in (b)(iii). Estimate this new value. *[1]*

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(iii) Suggest why your answer to (d)(ii) is only an estimate. *[1]*

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A2. This question is about ideal gases.

(a) State what is meant by an ideal gas. *[1]*

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(b) For an ideal gas

(i) define *internal energy.* *[1]*

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(ii) state and explain how the internal energy and the absolute (kelvin) temperature are related. *[2]*

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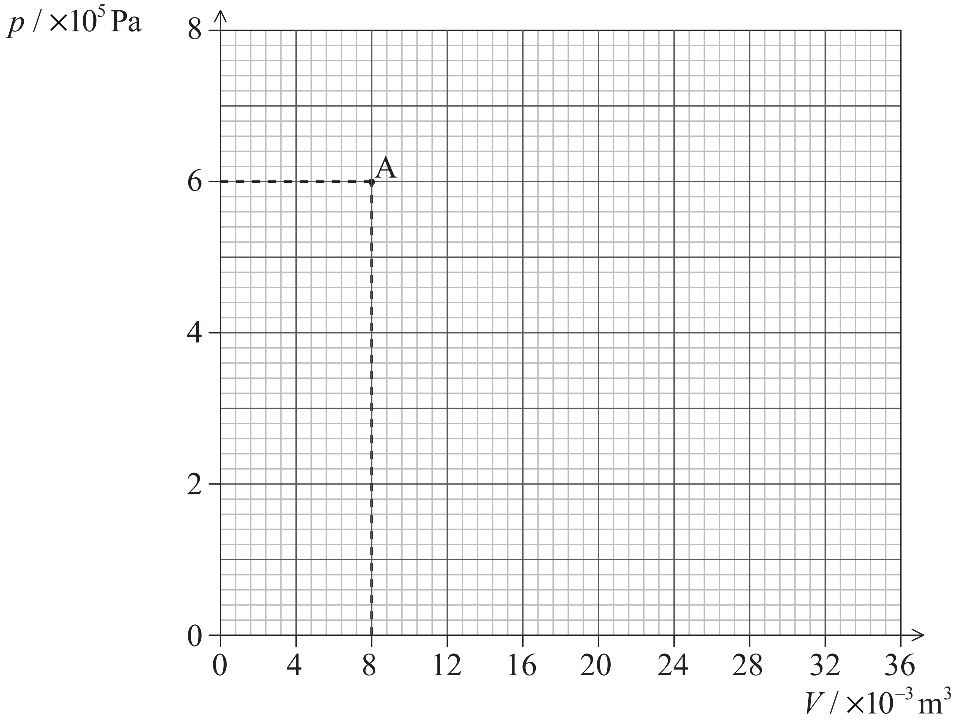
(Question A2 continued)

(c) Point A in the *p*-*V* diagram below represents the state of an ideal gas.



The gas expands at constant temperature from state A to state B. The volume of the gas in state B is 24×10^{-3} m^3.

(i) Calculate the pressure of the gas in state B. *[1]*

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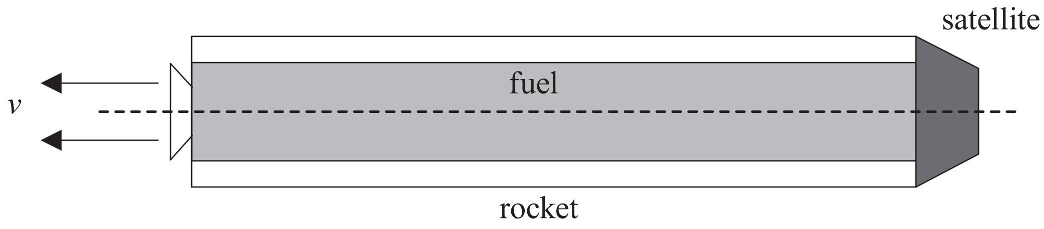
(ii) On the axes above label with the letter B the new state of the gas. *[1]*

(iii) Draw a line to show the variation with volume *V* of the pressure *p* of the gas as the gas expands from state A to state B. *[1]*

A3. This question is about momentum.

A rocket in outer space far from any other masses is used to propel a satellite. At $t=0$ the engines are turned on and gases leave the rear of the rocket with speed $v=7.2\times10^3\,\text{m s}^{-1}$ relative to the rocket. The gases are ejected at a constant rate of $1.4\,\text{kg s}^{-1}$. The mass of the rocket (including fuel) at $t=0$ is $280\,\text{kg}$.



(a) Explain, in terms of Newton's laws of motion, why the rocket will accelerate. *[2]*

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(b) Outline how the law of conservation of momentum applies to the motion of the rocket. *[2]*

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(c) Estimate the speed of the rocket at $t=1.0\,\text{s}$. *[3]*

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SECTION B

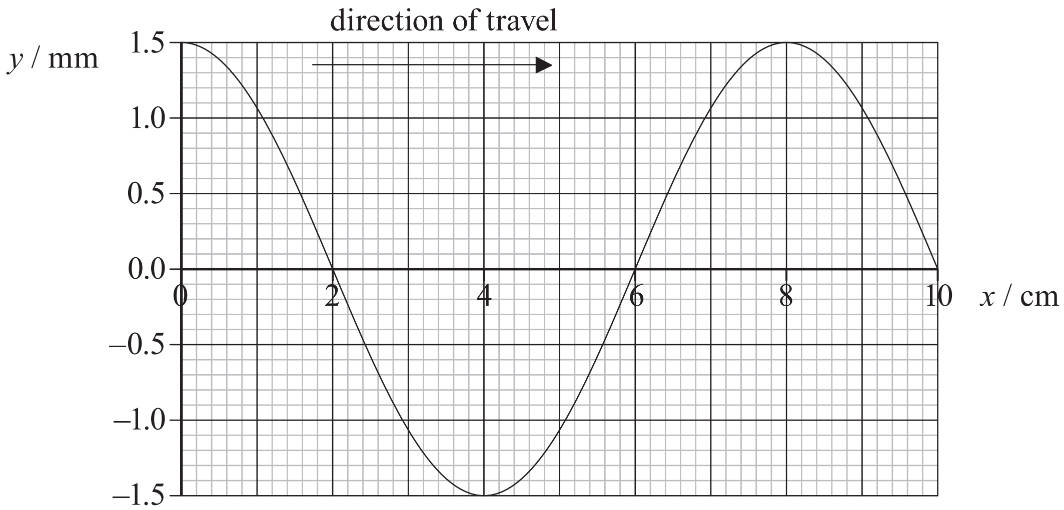
This section consists of three questions: B1, B2 and B3. Answer ***one*** *question.*

B1. This question is in **two** parts. **Part 1** is about wave motion. **Part 2** is about mechanics.

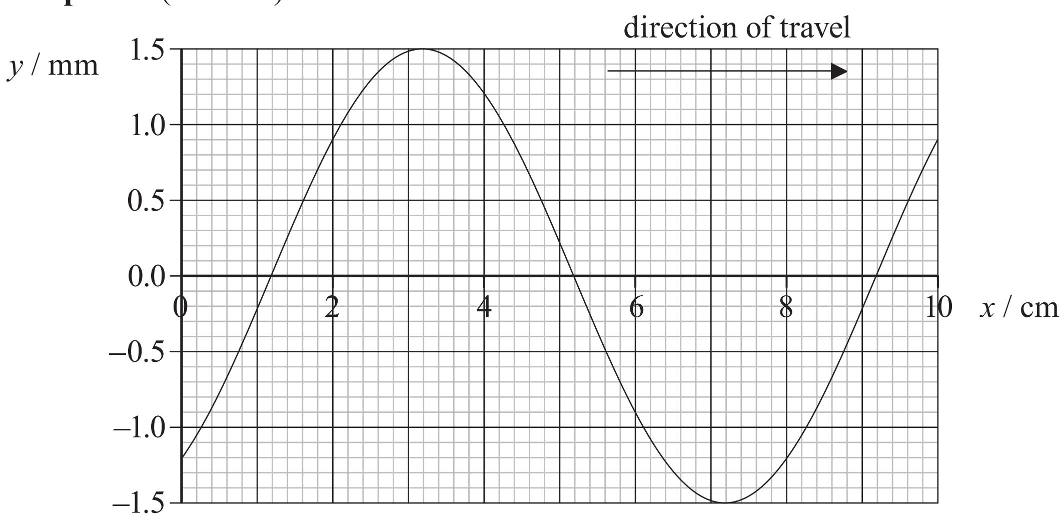
Part 1 Wave motion

(a) A wave is travelling on a string in the x direction. The two graphs show the variation with distance x of the displacement y of the string. Graph 1 corresponds to time $t=0$ and graph 2 to time $t=0.20\,\text{s}$.

Graph 1 ($t=0$)



Graph 2 ($t=0.20\,\text{s}$)



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(Question B1, part 1 continued)

The period of the wave is longer than 0.20 s.

Use the graphs to determine, for this wave,

(i) the amplitude. *[1]*

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(ii) the wavelength. *[1]*

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(iii) the speed. *[2]*

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(iv) the frequency. *[1]*

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(b) State **two** differences between a travelling wave and a standing wave. *[2]*

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(c) Explain what is meant by wave speed with reference to

(i) travelling waves. *[1]*

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(ii) standing waves. *[2]*

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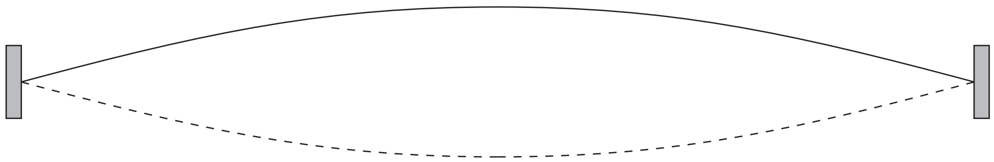
(Question B1, part 1 continued)

(d) The ends of a string are kept fixed and a standing wave is established on the string as represented in the diagram below.



The standing wave causes a sound wave.

(i) Explain how the standing wave creates a sound wave. *[2]*

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(ii) The speed of sound in air is $340\,m\,s^{-1}$. The length of the string is 0.80 m and the speed of the wave on the string is $240\,m\,s^{-1}$.

Calculate the wavelength of the sound in air. *[3]*

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(This question continues on the following page)

(Question B1 continued)

Part 2	Mechanics

(a)	Define *power*.	*[1]*

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(b)	A car is travelling along a horizontal straight road. The power developed by the engine of the car at speed v is P. The force on the car due to the engine is F.

Deduce that

$$P = Fv.$$

[2]

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(This question continues on the following page)

(Question B1, part 2 continued)

(c) A car of mass 1200 kg starts from rest and travels along a horizontal straight road. The engine of the car develops a constant power of 54 kW. All the energy produced by the engine goes into increasing the kinetic energy of the car.

Calculate for the car at $t = 5.0$ s the

(i) instantaneous speed. *[2]*

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(ii) instantaneous acceleration. *[3]*

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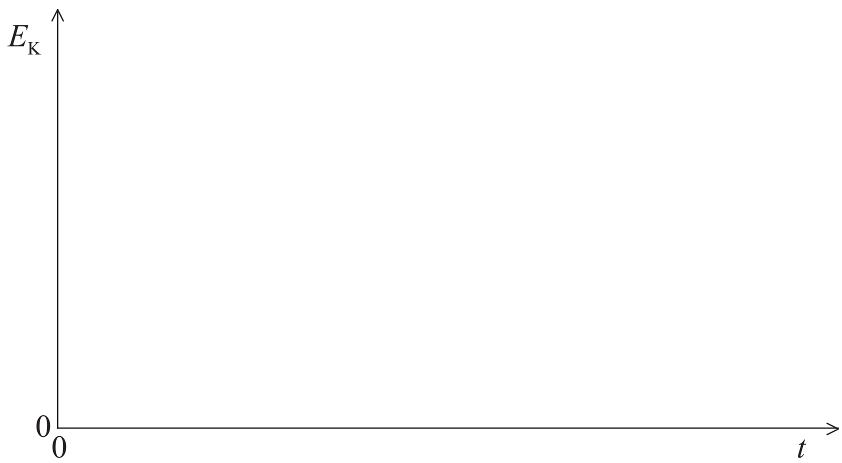
(d) On the axes below draw a sketch graph to show the variation with time t of the kinetic energy E_K of the car in (c). (This is a sketch graph you do not need to add values to the axes.) *[2]*



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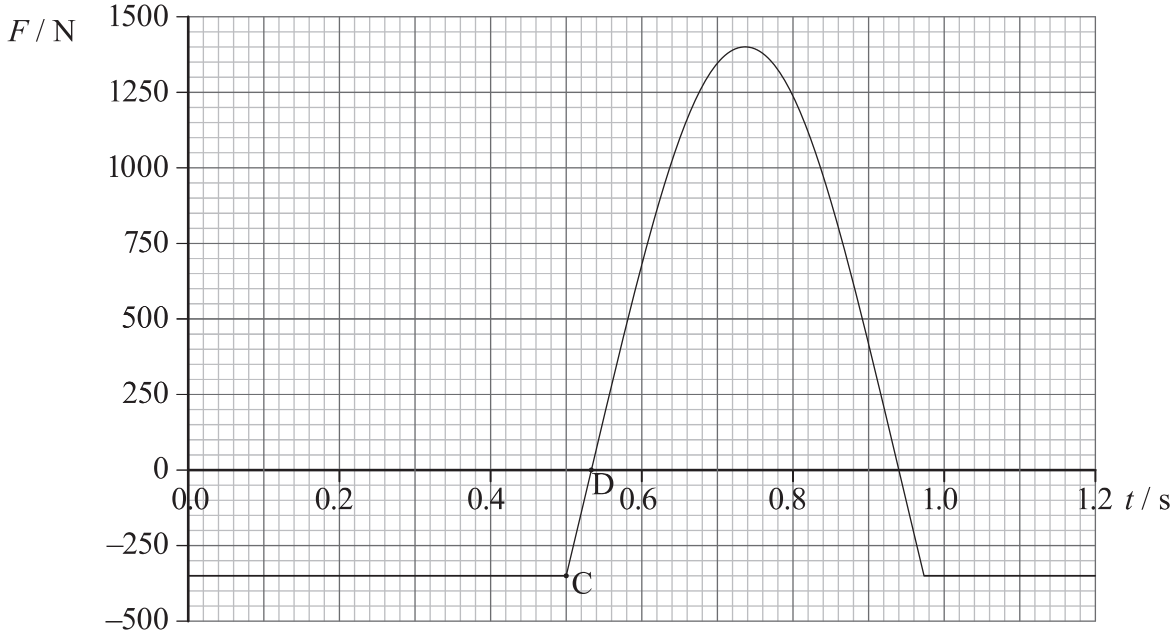
B2. This question is in **two** parts. **Part 1** is about mechanics. **Part 2** is about radioactivity.

Part 1 Mechanics

(a) A girl falls from rest on to the horizontal surface of a trampoline.

The graph below shows the variation with time t of the net force F exerted on the girl before, during and after contact with the trampoline.



The girl first makes contact with the trampoline at point C.

Use data from the graph to calculate the

(i) mass of the girl. *[1]*

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(ii) speed of the girl just before she lands on the trampoline. *[2]*

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(This question continues on the following page)

(Question B2, part 1 continued)

(iii) initial height above the surface of the trampoline from which the girl falls. *[2]*

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(iv) magnitude of the maximum acceleration of the girl for the time she is in contact with the trampoline. *[2]*

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(b) The girl has a maximum speed at point D as shown on the graph.

For the time between point C and point D

(i) explain why the speed of the girl is increasing. *[2]*

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(ii) deduce that the change in momentum of the girl is approximately 5 N s. *[2]*

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(iii) estimate the maximum speed of the girl. *[2]*

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(Question B2 continued)

Part 2 Radioactivity

(a) Nuclei of the carbon isotope, C-14, are continuously produced in the atmosphere by the collision of neutrons with nuclei of nitrogen N-14.

(i) Define the term *isotope*. *[1]*

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(ii) State the nuclear reaction equation for the production of a nucleus of C-14 (proton (atomic) number of carbon = 6, proton (atomic) number of nitrogen = 7). *[2]*

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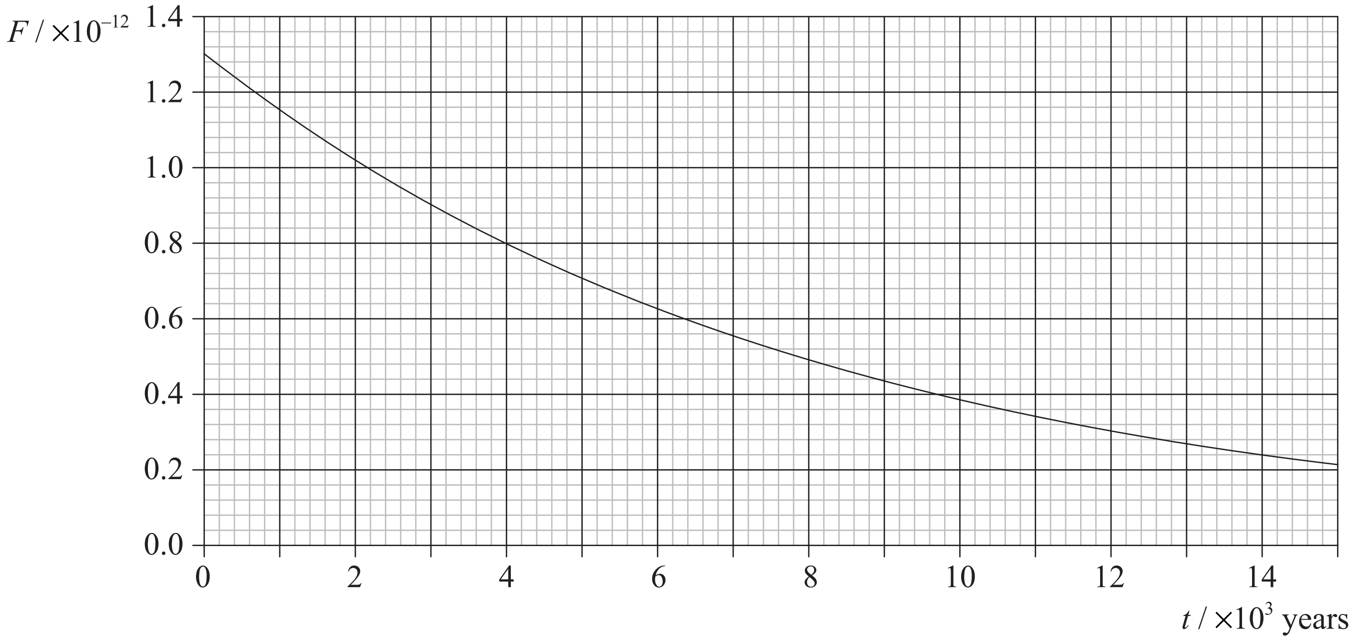
(Question B2, part 2 continued)

(b) In a living animal the fraction $F = \dfrac{\text{number of } {}^{14}_{6}\text{C nuclei}}{\text{number of } {}^{12}_{6}\text{C nuclei}}$ is constant due to the replacement of carbon in the bone.

The graph shows the variation with time t (since death) of the fraction F in the bone of a dead animal.



Explain why the fraction F does not stay constant in the bone of a dead animal. *[2]*

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(Question B2, part 2 continued)

(c) Use the graph in (b) to determine the

(i) value of the fraction F for the bone of an animal whilst it was alive. *[1]*

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(ii) half-life of carbon C-14. *[2]*

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(d) Estimate the age of a bone for which $F = 6.0 \times 10^{-13}$. *[2]*

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(e) Suggest why a graph of F versus t is inappropriate for finding the age of a dinosaur bone. *[2]*

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B3. This question is in **two** parts. **Part 1** is about calorimetry. **Part 2** is about electricity and magnetism.

Part 1 Calorimetry

(a) Define *heat capacity* of a body. *[1]*

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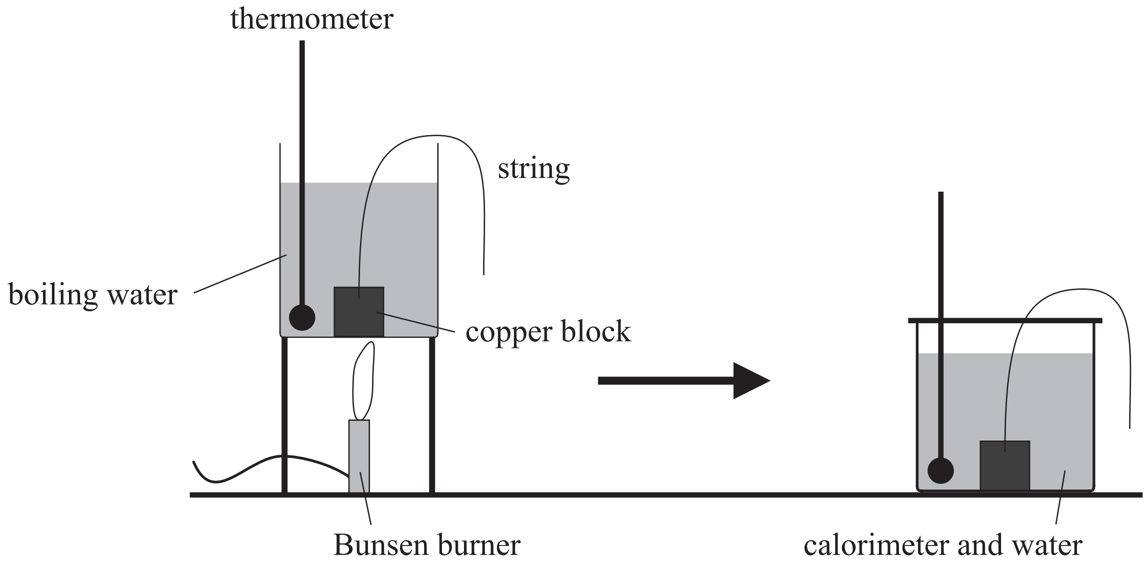
(Question B3, part 1 continued)

(b) The diagram below shows an experiment to measure the heat capacity of a block of copper.



The block of copper is first placed in a container of boiling water. The block is then transferred to an insulated calorimeter containing water. The following data are available.

Temperature of boiling water	100 °C
Initial temperature of water in calorimeter	22 °C
Final temperature of water in calorimeter	28 °C
Heat capacity of calorimeter and water	950 JK^{-1}

Determine the

(i) total thermal energy absorbed by the calorimeter and the water. *[2]*

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(ii) heat capacity of the copper block. *[2]*

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(Question B3, part 1 continued)

(c) State a further measurement that must be made in order to determine the specific heat capacity of copper. *[1]*

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(d) State **two** sources of error in this experiment. *[2]*

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(Question B3 continued)

Part 2 Electricity and magnetism

Electricity

(a) Define *electromotive force* (e.m.f.). *[1]*

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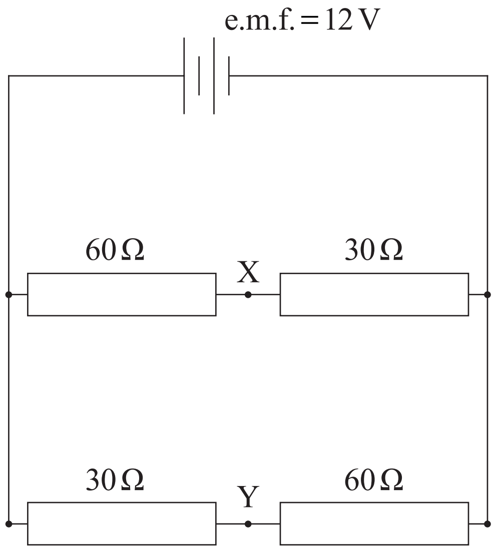
(b) In the circuit below the battery has an e.m.f. of 12 V and an internal resistance of 5.0 Ω.



Calculate the

(i) total resistance of the circuit. *[3]*

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(ii) current in the internal resistance. *[1]*

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(This question continues on the following page)

(Question B3, part 2 continued)

(iii) total power dissipated in the circuit. *[2]*

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(iv) potential difference between points X and Y. *[3]*

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(c) A real (*i.e.* non-ideal) voltmeter is connected across points X and Y in the circuit in (b). Explain why the reading of this voltmeter will not be the same as your answer to (b)(iv). *[2]*

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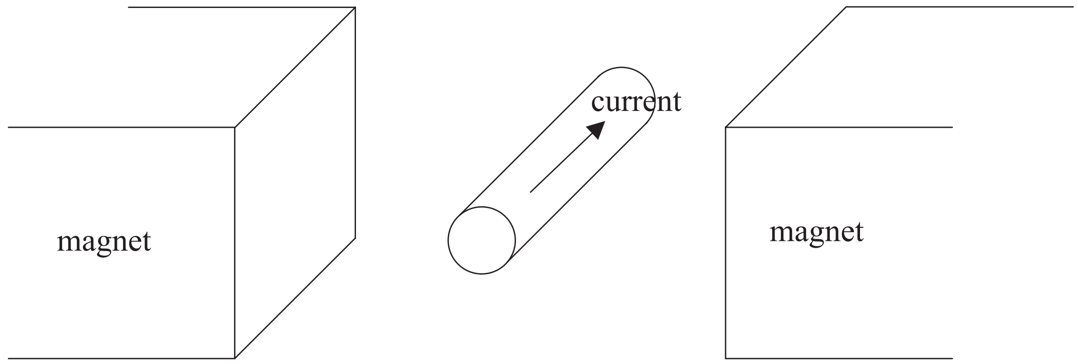
(Question B3, part 2 continued)

Magnetism

(d) A current carrying rod is held horizontally between the poles of a magnet by a magnetic force.



(i) On the diagram above label with the letter N the north pole of the magnet. Explain your choice. *[1]*

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(ii) The weight of the rod is 4.0 N and its length is 0.80 m. The magnitude of the magnetic field strength is 0.20 T. Determine the current in the rod. *[2]*

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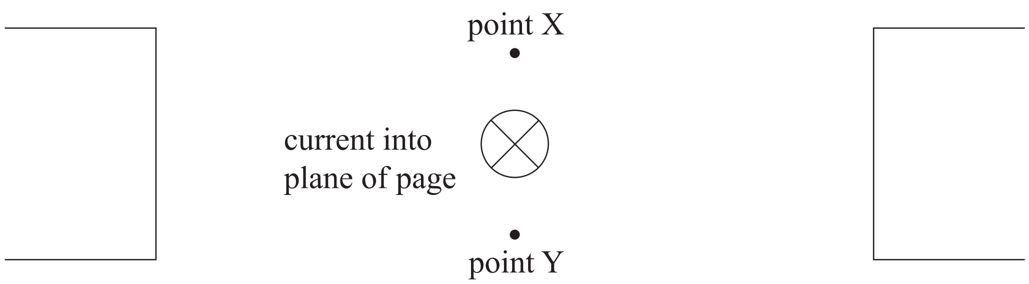
(iii) The diagram below shows two points X and Y that are at equal distances from the current carrying rod in (d).



State and explain at which point (X or Y) the magnetic field strength is greatest. *[2]*

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