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

N05/4/PHYSI/SP2/ENG/TZ0/XX

88056505

PHYSICS
STANDARD LEVEL
PAPER 2

Thursday 17 November 2005 (afternoon)

1 hour 15 minutes

Candidate session number

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INSTRUCTIONS TO CANDIDATES

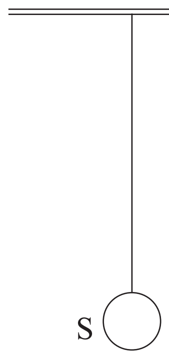
- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Section A: answer all of Section A in the spaces provided.
- Section B: answer one question from Section B in the spaces provided.
- At the end of the examination, indicate the numbers of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

SECTION A

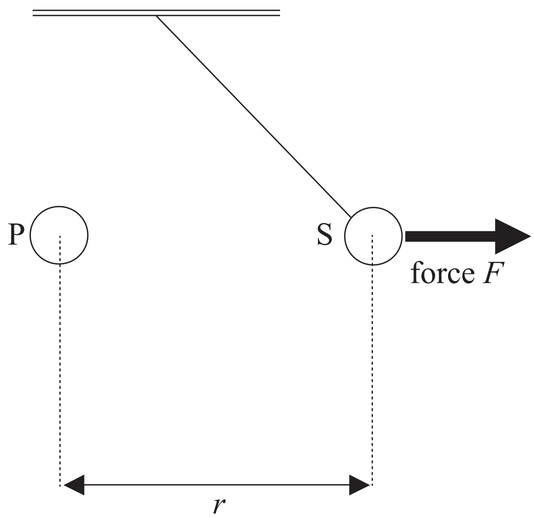
*Answer **all** the questions in the spaces provided.*

A1. This question is about an electrostatics experiment to investigate how the force between two charges varies with the distance between them.

A small charged sphere S hangs vertically from an insulating thread as shown below.



A second identically charged sphere P is brought close to S. S is repelled as shown below.



The magnitude of the electrostatic force on sphere S is F. The separation between the two spheres is r.

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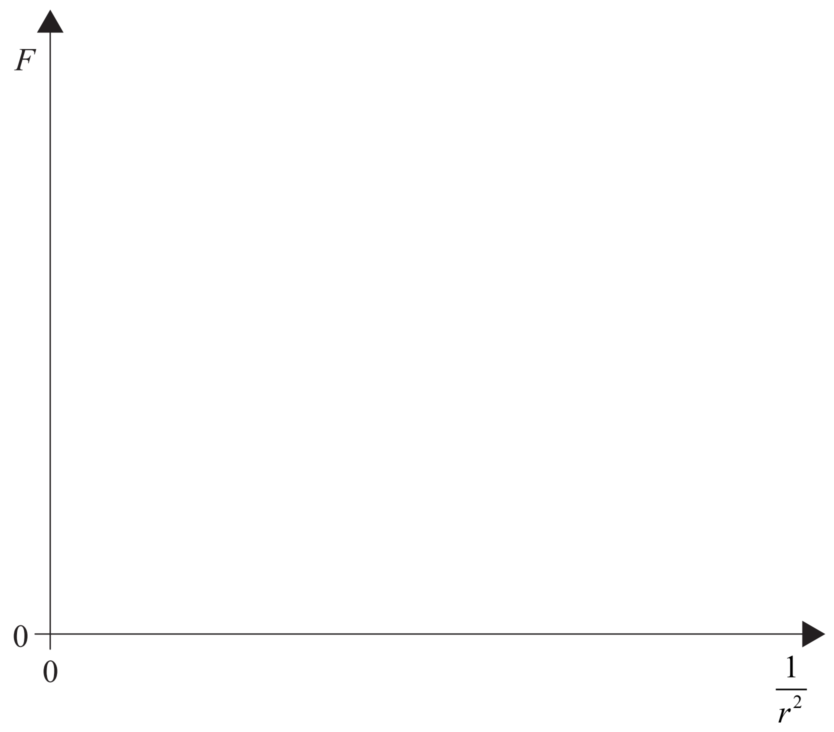
(Question A1 continued)

(a) On the axes below draw a sketch graph to show how, based on Coulomb's law, you would expect F to vary with $\frac{1}{r^2}$. *[2]*



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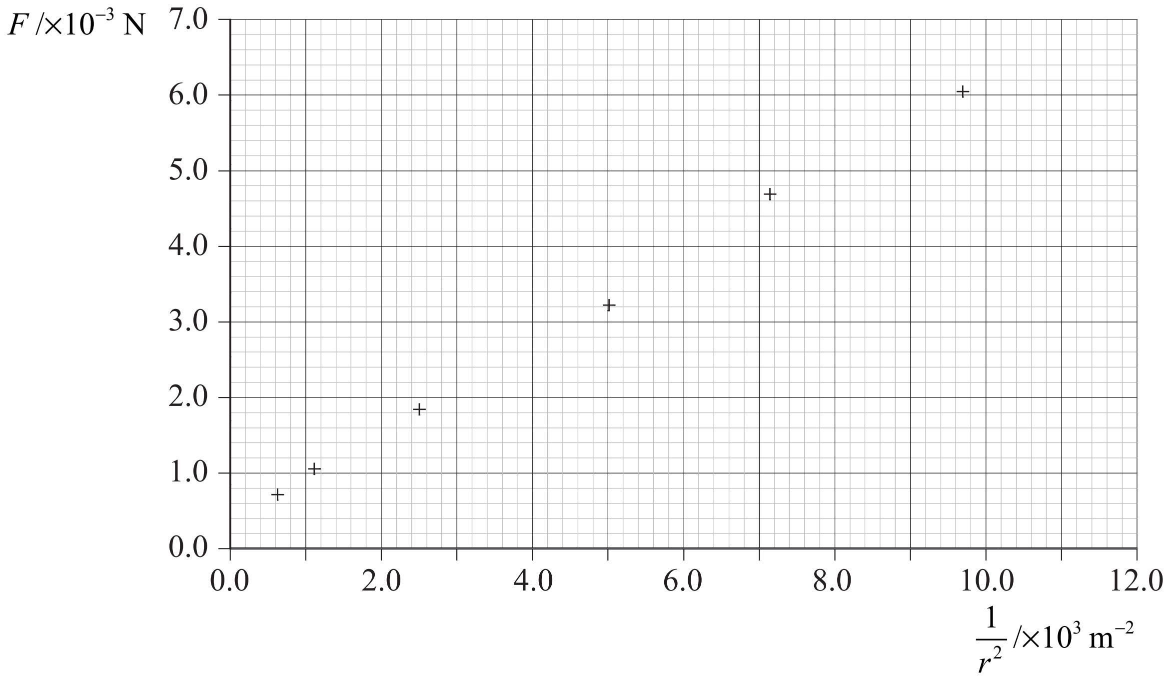
(Question A1 continued)

Values of F are determined for different values of r. The variation with $\frac{1}{r^2}$ of these values is shown below. The estimated uncertainties in these values are negligible.



(b) (i) Draw the best-fit line for these data points. *[2]*

(ii) Use the graph to explain whether, in the experiment, there are random errors, systematic errors or both. *[3]*

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(iii) Calculate the gradient of the line drawn in (b) (i). *[2]*

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(Question A1 continued)

(iv) The magnitude of the charge on each sphere is the same. Use your answer to (b) (iii) to calculate this magnitude. *[4]*

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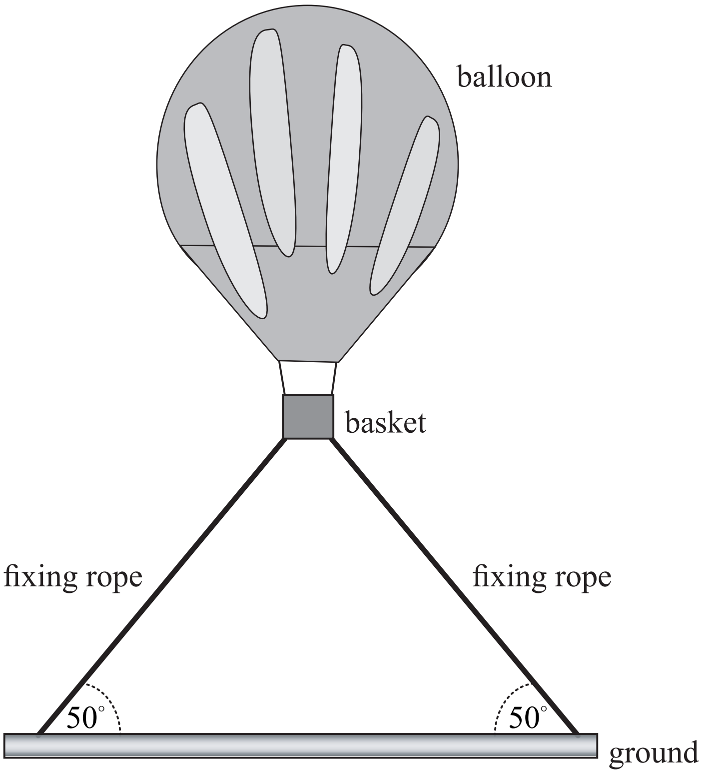
A2. This question is about a balloon used to carry scientific equipment.

The diagram below represents a balloon just before take-off. The balloon's basket is attached to the ground by two fixing ropes.



There is a force *F* vertically upwards of 2.15×10^3 N on the balloon. The total mass of the balloon and its basket is 1.95×10^2 kg.

(a) State the magnitude of the resultant force on the balloon when it is attached to the ground. *[1]*

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(b) Calculate the tension in **either** of the fixing ropes. *[3]*

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(Question A2 continued)

(c) The fixing ropes are released and the balloon accelerates upwards. Calculate the magnitude of this initial acceleration. *[2]*

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(d) The balloon reaches a terminal speed 10 seconds after take-off. The upward force F remains constant. Describe how the magnitude of air friction on the balloon varies during the first 10 seconds of its flight. *[2]*

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A3. This question is about electric fields.

(a) Define *electric field strength*. *[2]*

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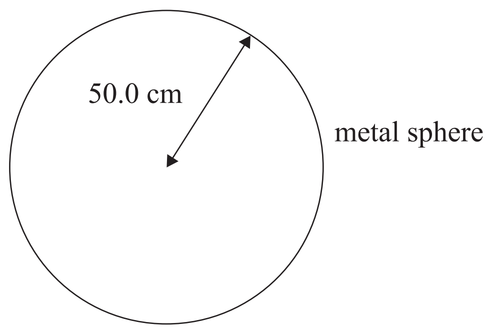
(b) An isolated metal sphere of radius 50.0 cm has a positive charge. On the diagram below draw lines to represent the electric field outside the sphere. *[2]*



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 electrical circuits and **Part 2** is about kinematics.

Part 1 Electrical circuits

Andrew is set the task of measuring the current-voltage (*I*-*V*) characteristics of a filament lamp. The following equipment and information are available.

	Information
Battery	e.m.f. = 3.0 V, negligible internal resistance
Filament lamp	marked "3 V, 0.2 A"
Voltmeter	resistance = 30 kΩ, reads values between 0.0 and 3.0 V
Ammeter	resistance = 0.1 Ω, reads values between 0.0 and 0.5 A
Potentiometer	resistance = 100 Ω

(a) For the filament lamp operating at normal brightness, calculate

(i) its resistance. *[1]*

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(ii) its power dissipation. *[1]*

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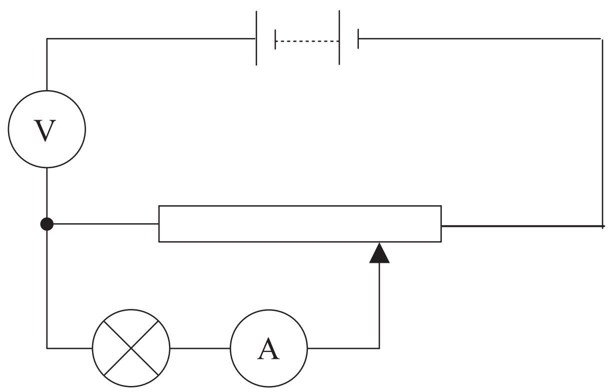
(Question B1, part 1 continued)

Andrew sets up the following **incorrect** circuit.



(b) (i) Explain why the lamp will not light. *[2]*

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(ii) State the approximate reading on the voltmeter. Explain your answer. *[2]*

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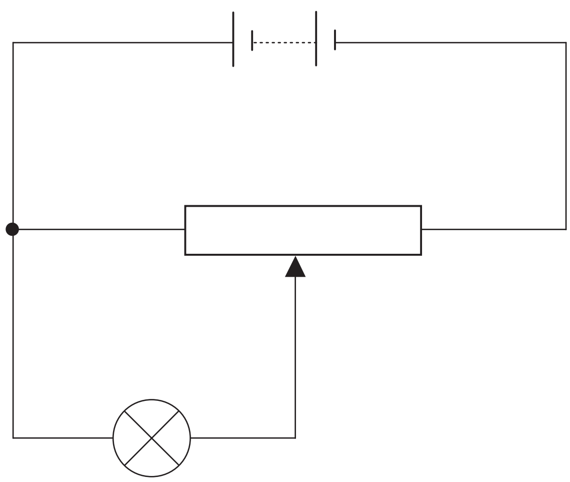
(c) On the circuit diagram below, add circuit symbols to show the correct position of the ammeter and of the voltmeter in order to measure the *I-V* characteristics of the lamp. *[2]*



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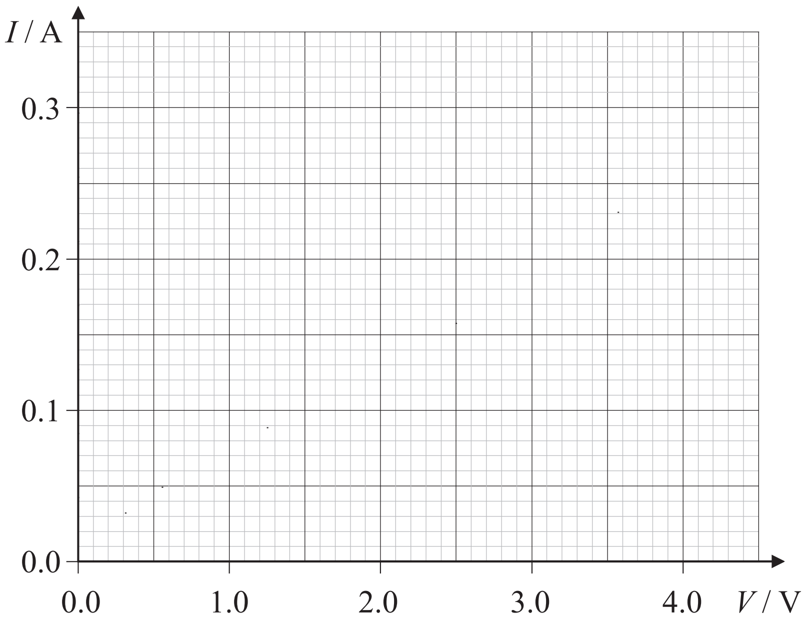
(Question B1, part 1 continued)

(d) On the axes below draw a sketch graph to show the *I-V* characteristics for this filament lamp. *[4]*



(e) Explain the shape of the graph that you have drawn in (d). *[2]*

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(Question B1 continued)

Part 2 Kinematics

(a) State the principle of conservation of energy. *[1]*

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(b) An aircraft accelerates from rest along a horizontal straight runway and then takes-off. Discuss how the principle of conservation of energy applies to the energy changes that take place while the aircraft is accelerating along the runway. *[3]*

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(c) The mass of the aircraft is 8.0×10^{3} kg.

(i) The average resultant force on the aircraft while travelling along the runway is 70 kN. The speed of the aircraft just as it lifts off is $75\,\text{m}\,\text{s}^{-1}$. Estimate the distance travelled along the runway. *[3]*

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(ii) The aircraft climbs to a height of 1250 m. Calculate the potential energy gained during the climb. *[1]*

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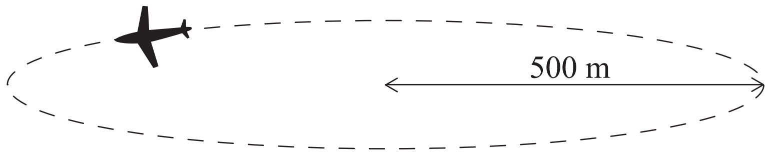
(Question B1, part 2 continued)

When approaching its destination, the pilot puts the aircraft into a holding pattern. This means the aircraft flies at a constant speed of $90\,m\,s^{-1}$ in a horizontal circle of radius 500 m as shown in the diagram below.



(d) For the aircraft in the holding pattern,

(i) calculate the magnitude of the resultant force on the aircraft. *[2]*

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(ii) state the direction of the resultant force. *[1]*

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B2. This question is in **two** parts. **Part 1** is about the physics of cooling and **Part 2** is about nuclear binding energy and nuclear decay.

Part 1 The physics of cooling

(a) Explain what is meant by *the temperature of a substance*. *[2]*

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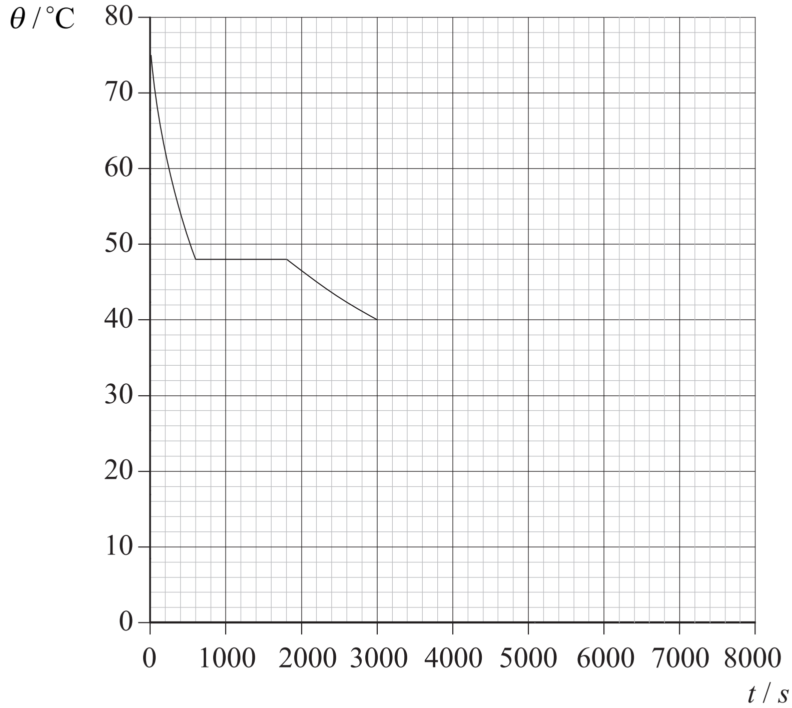
A thermometer is placed in a liquid contained in an open beaker. The reading of the thermometer is recorded at regular intervals. The variation with time t of the temperature θ is shown below.



(b) The temperature of the surroundings is 20 °C. On the graph continue the line to show the variation with time of the temperature for the next 3000 s. *[2]*

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(Question B2, part 1 continued)

(c) By reference to the graph, state and explain the rate of loss of thermal energy from the substance between

(i) 0 and 600 s. *[2]*

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(ii) 600 and 1800 s. *[4]*

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The mass of the liquid is 0.11 kg and the specific heat capacity of the liquid is $1300\,\mathrm{J\,kg^{-1}\,K^{-1}}$.

(d) (i) Use the graph to deduce that the rate of loss of thermal energy at time $t = 600$ s is approximately 4 W. *[3]*

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(ii) Calculate the specific latent heat of fusion of the liquid. *[3]*

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(Question B2 continued)

Part 2 Nuclear binding energy and nuclear decay

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

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(b) Define what is meant by the *binding energy* of a nucleus. *[1]*

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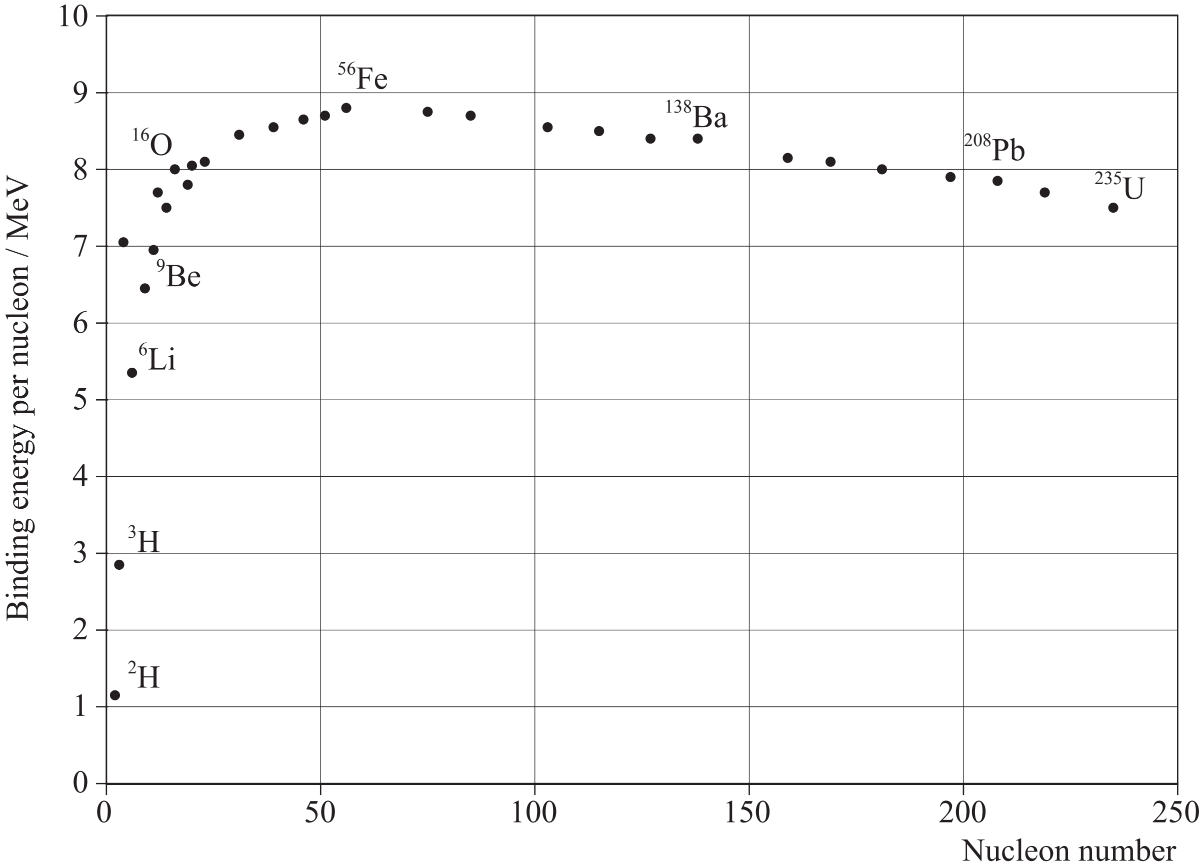
(Question B2, part 2 continued)

The graph below shows the variation with nucleon (mass) number of the binding energy per nucleon.



(c) Use the graph to explain why energy can be released in both the fission and the fusion processes. *[3]*

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(Question B2, part 2 continued)

(d) A sample of carbon-11 has an initial mass of 4.0×10^{-15} kg. Carbon-11 has a half-life of approximately 20 minutes. Calculate the mass of carbon-11 remaining after one hour has elapsed. *[2]*

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(e) Uranium-238, ${}^{238}_{92}\mathrm{U}$, undergoes α-decay to form an isotope of thorium. Write down the nuclear equation for this decay. *[2]*

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B3. This question is in **two** parts. **Part 1** is about standing waves and **Part 2** is about momentum.

Part 1 Standing waves

(a) State the difference between standing waves and travelling waves. *[2]*

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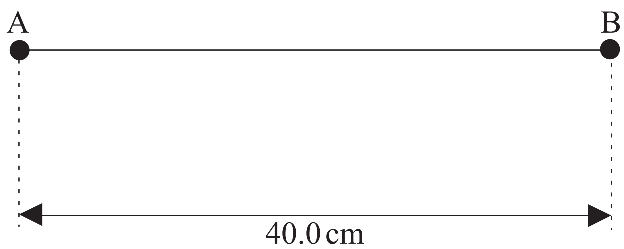
A cord is held under tension between two fixed points A and B. The distance AB is 40.0 cm.



(b) (i) State the wavelength of the fundamental (first harmonic) resonant mode. *[1]*

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(ii) On the diagram above, sketch the shape of the cord when it vibrates in the second harmonic resonant mode. *[1]*

(iii) Explain why it is not possible to have resonant modes of frequencies between the first and second harmonics. *[2]*

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(Question B3, part 1 continued)

(iv) The speed of the wave on the string is $200\,m\,s^{-1}$. Calculate the frequency of the second harmonic. *[2]*

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(v) For a given maximum amplitude the energy of a standing wave is proportional to $(\text{frequency})^2$. Calculate the ratio

$$\frac{\text{energy of the second harmonic}}{\text{energy of the fundamental}},$$

assuming both harmonics have the same maximum amplitude. *[2]*

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(Question B3 continued)

Part 2 Linear momentum

(a) Define

(i) *linear momentum.* *[1]*

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(ii) *impulse.* *[1]*

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(b) Explain whether momentum and impulse are scalar or vector quantities. *[1]*

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(c) By reference to Newton's laws of motion, deduce that when two particles collide, momentum is conserved. *[5]*

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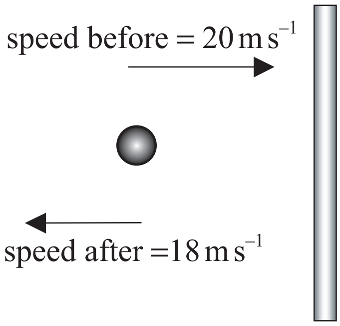
(Question B3, part 2 continued)

A rubber ball of mass 50 g is thrown towards a vertical wall. It strikes the wall at a horizontal speed of 20 m s^{-1} and bounces back with a horizontal speed of 18 m s^{-1} as shown below.



The ball is in contact with the wall for 0.080 s.

(d) (i) Calculate the change in momentum of the ball. *[2]*

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(ii) Calculate the average force exerted by the ball on the wall. *[2]*

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(iii) Suggest, in terms of Newton's laws of motion, why a steel ball of the same mass and the same initial horizontal speed exerts a greater force on the wall. *[3]*

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