M15/4/PHYSI/SP2/ENG/TZ2/XX

Diploma Programme
Programme du diplôme
Programa del Diploma

Physics
Standard level
Paper 2

Friday 8 May 2015 (morning)

1 hour 15 minutes

Candidate session number

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]**.

26 pages

2215 – 6517

International Baccalaureate
Baccalauréat International
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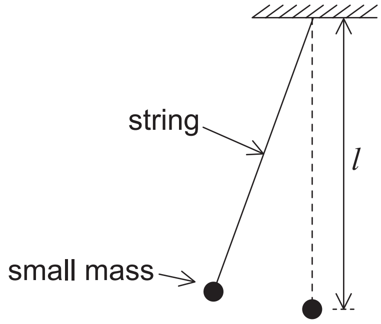
Section A

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

1. Data analysis question.

A simple pendulum of length l consists of a small mass attached to the end of a light string.



The time T taken for the mass to swing through one cycle is given by

$$T = 2\pi\sqrt{\frac{l}{g}}$$

where g is the acceleration due to gravity.

(a) A student measures T for one length l to determine the value of g. Time $T = 1.9\,\text{s} \pm 0.1\,\text{s}$ and length $l = 0.880\,\text{m} \pm 0.001\,\text{m}$. Calculate the fractional uncertainty in g. [2]

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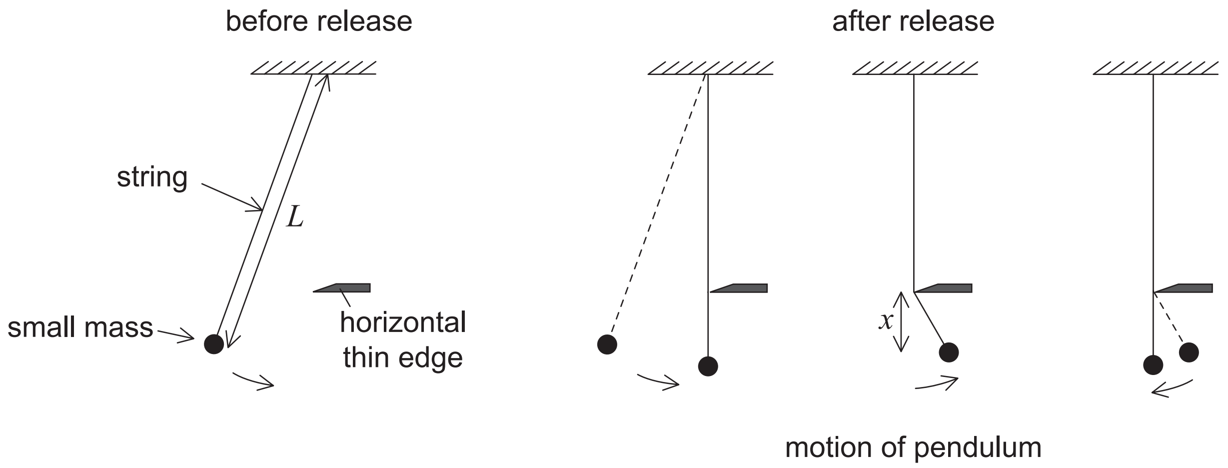
(Question 1 continued)

(b) The student modifies the simple pendulum of length L so that, after release, it swings for a quarter of a cycle before the string strikes a horizontal thin edge. For the next half cycle, the pendulum swings with a shorter length x. The string then leaves the horizontal thin edge to swing with its original length L.



The length L of the string is kept constant during the experiment. The vertical position of the horizontal thin edge is varied to change x.

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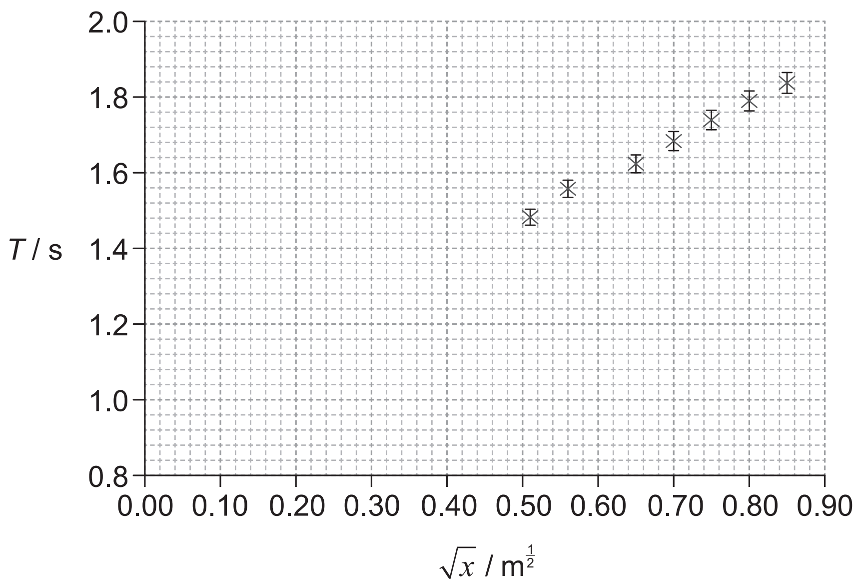
(Question 1 continued)

The graph shows the variation of the time period with $\sqrt{x}$ for data obtained by the student together with error bars for the data points. The error in $\sqrt{x}$ is too small to be shown.



(i) Deduce that the time period for one complete oscillation of the pendulum is given by

$$T = \frac{\pi}{\sqrt{g}}\left(\sqrt{L} + \sqrt{x}\right).$$ [1]

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(ii) On the graph, draw the best-fit line for the data. [1]

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(Question 1 continued)

(iii) Determine the gradient of the graph. [3]

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(iv) State the value of the intercept on the *T*-axis. [1]

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(v) The equation of a straight line is $y = mx + c$. Determine, using your answers to (b)(iii) and (b)(iv), the intercept on the $\sqrt{x}$-axis. [2]

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(vi) Calculate L. [1]

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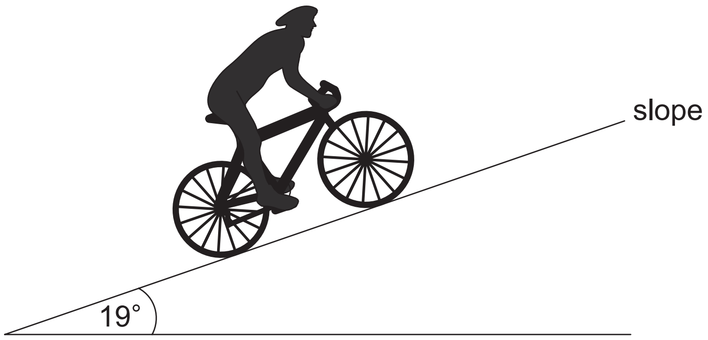
2. This question is about the motion of a bicycle.

A cyclist is moving up a slope that is at an angle of 19° to the horizontal. The mass of the cyclist and the bicycle is 85 kg.



(a) Calculate the

(i) component of the weight of the cyclist and bicycle parallel to the slope. [2]

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(ii) normal reaction force on the bicycle from the slope. [1]

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(b) At the bottom of the slope the cyclist has a speed of 5.5 m s^{-1}. The cyclist stops pedalling and applies the brakes which provide an additional decelerating force of 250 N. Determine the distance taken for the cyclist to stop. Assume air resistance is negligible and that there are no other frictional forces. [4]

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3. This question is about internal energy.

(a) Distinguish between thermal energy (heat) and temperature. [3]

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(b) (i) Mathilde raises the temperature of water in a electric kettle to boiling point. Once the water is boiling steadily, she measures the change in the mass of the kettle and its contents over a period of time.

The following data are available.

Initial mass of kettle and water	$= 1.880\,\text{kg}$
Final mass of kettle and water	$= 1.580\,\text{kg}$
Time between mass measurements	$= 300\,\text{s}$
Power dissipation in the kettle	$= 2.5\,\text{kW}$

Determine the specific latent heat of vaporization of water. [2]

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(ii) Outline why your answer to (b)(i) is an overestimate of the specific latent heat of vaporization of water. [2]

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Section B

This section consists of three questions: 4, 5 and 6. Answer **one** question. Write your answers in the boxes provided.

4. This question is in **two** parts. **Part 1** is about renewable energy. **Part 2** is about nuclear energy and radioactivity.

Part 1 Renewable energy

A small coastal community decides to use a wind farm consisting of five identical wind turbines to generate part of its energy. At the proposed site, the average wind speed is 8.5 $m\,s^{-1}$ and the density of air is 1.3 $kg\,m^{-3}$. The maximum power required from the wind farm is 0.75 MW. Each turbine has an efficiency of 30 %.

(a) (i) Determine the diameter that will be required for the turbine blades to achieve the maximum power of 0.75 MW. [3]

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(ii) State **one** reason why, in practice, a diameter larger than your answer to (a)(i) is required. [1]

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(iii) Outline why the individual turbines should not be placed close to each other. [2]

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(Question 4, part 1 continued)

(iv) Some members of the community propose that the wind farm should be located at sea rather than on land. Evaluate this proposal. [2]

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(Question 4, part 1 continued)

(b) Currently, a nearby coal-fired power station generates energy for the community. Less coal will be burnt at the power station if the wind farm is constructed.

(i) The energy density of coal is $35\,\text{MJ}\,\text{kg}^{-1}$. Estimate the minimum mass of coal that can be saved every hour when the wind farm is producing its full output. [2]

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(ii) One advantage of the reduction in coal consumption is that less carbon dioxide will be released into the atmosphere. State **one** other advantage and **one** disadvantage of constructing the wind farm. [2]

Advantage:

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Disadvantage:

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(iii) Suggest the likely effect on the Earth's temperature of a reduction in the concentration of atmospheric greenhouse gases. [3]

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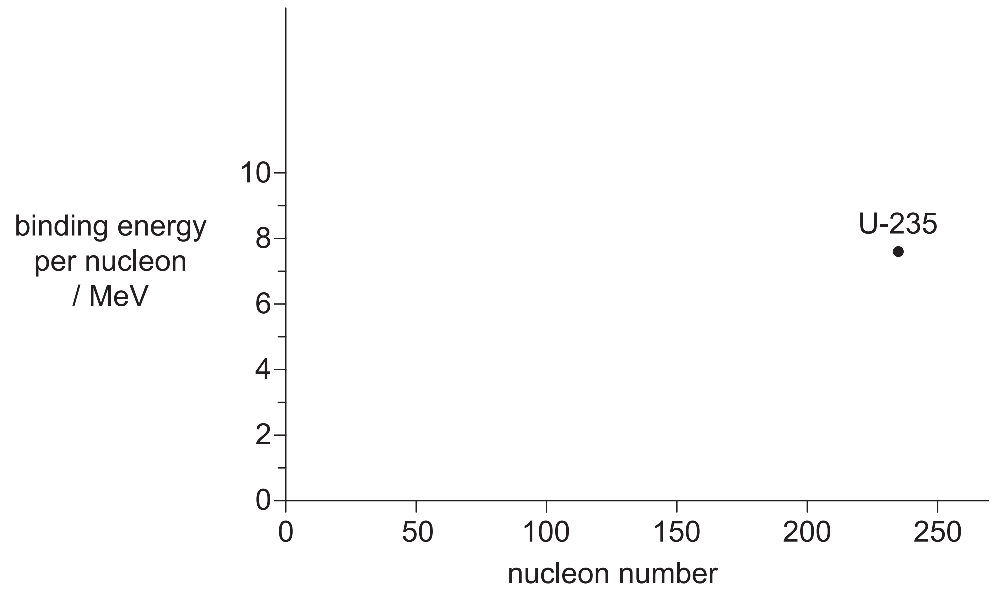
(Question 4 continued)

Part 2 Nuclear energy and radioactivity

The graph shows the variation of binding energy per nucleon with nucleon number. The position for uranium-235 (U-235) is shown.



(c) State what is meant by the binding energy of a nucleus. [1]

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(d) (i) On the axes, sketch a graph showing the variation of nucleon number with the binding energy per nucleon. [2]

(ii) Explain, with reference to your graph, why energy is released during fission of U-235. [3]

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(This question continues on the following page)

(Question 4, part 2 continued)

(e) U-235 $\left({}^{235}_{92}\text{U}\right)$ can undergo alpha decay to form an isotope of thorium (Th).

(i) State the nuclear equation for this decay. [1]

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

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(iii) A sample of rock contains a mass of 5.6 mg of U-235 at the present day. The half-life of U-235 is 7.0×10^8 years. Calculate the initial mass of the U-235 if the rock sample was formed 2.1×10^9 years ago. [2]

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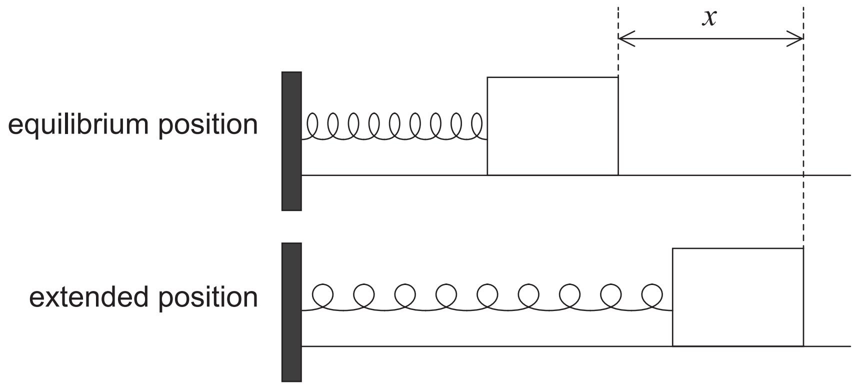
5. This question is in **two** parts. **Part 1** is about simple harmonic motion (SHM). **Part 2** is about current electricity.

Part 1 Simple harmonic motion (SHM)

An object is placed on a frictionless surface. The object is attached by a spring fixed at one end and oscillates at the end of the spring with simple harmonic motion (SHM).



The tension F in the spring is given by $F = kx$ where x is the extension of the spring and k is a constant.

(a) Show that $\omega^2 = \frac{k}{m}$. [2]

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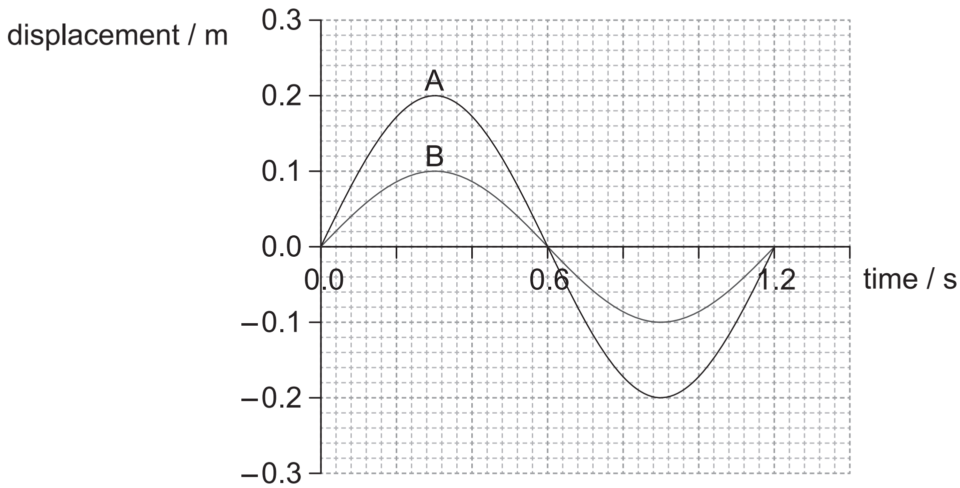
(Question 5, part 1 continued)

(b) One cycle of the variation of displacement with time is shown for two separate mass–spring systems, A and B.



(i) Calculate the frequency of the oscillation of A. [1]

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(ii) The springs used in A and B are identical. Show that the mass in A is equal to the mass in B. [2]

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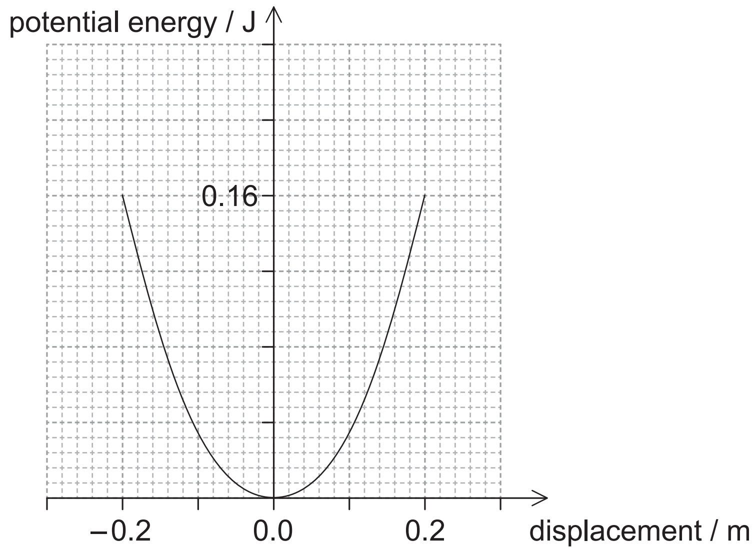
(Question 5, part 1 continued)

(c) The graph shows the variation of the potential energy of A with displacement.



On the axes,

(i) draw a graph to show the variation of kinetic energy with displacement for the mass in A. Label this A. [2]

(ii) sketch a graph to show the variation of kinetic energy with displacement for the mass in B. Label this B. [3]

(This question continues on the following page)

(Question 5 continued)

Part 2 Current electricity

(d) A 24 Ω resistor is made from a conducting wire.

(i) The diameter of the wire is 0.30 mm and the wire has a resistivity of 1.7×10^{-8} Ω m. Calculate the length of the wire. [2]

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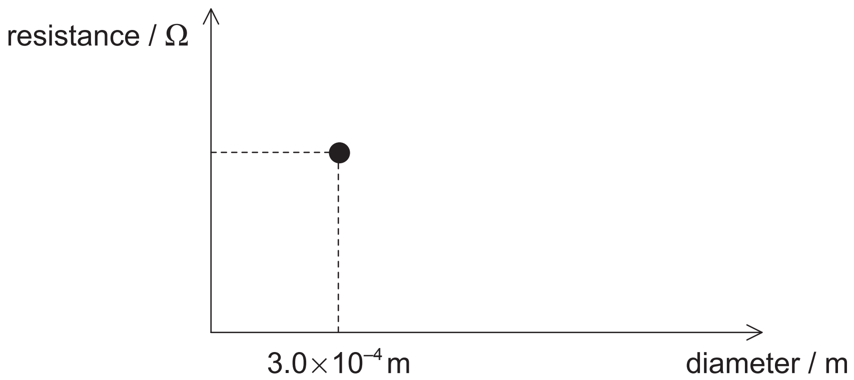
(ii) On the axes, draw a graph to show how the resistance of the wire in (d)(i) varies with the diameter of the wire when the length is constant. The data point for the diameter of 0.30 mm has already been plotted for you. [2]



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(Question 5, part 2 continued)

(e) The 24 Ω resistor is covered in an insulating material. Explain the reasons for the differences between the electrical properties of the insulating material and the electrical properties of the wire. [3]

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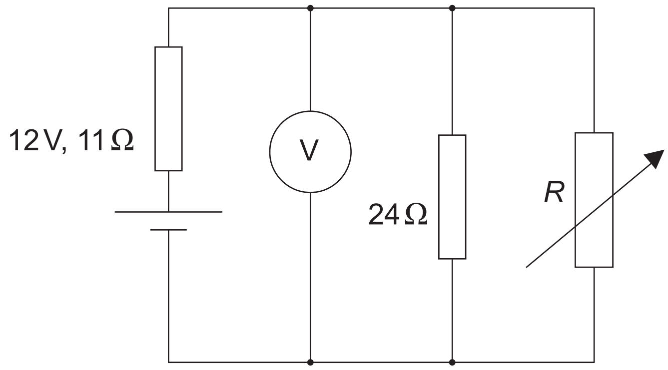
(Question 5, part 2 continued)

(f) An electric circuit consists of a supply connected to a 24 Ω resistor in parallel with a variable resistor of resistance *R*. The supply has an emf of 12 V and an internal resistance of 11 Ω.



Power supplies deliver maximum power to an external circuit when the resistance of the external circuit equals the internal resistance of the power supply.

(i) Determine the value of *R* for this circuit at which maximum power is delivered to the external circuit. [3]

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(ii) Calculate the reading on the voltmeter for the value of *R* you determined in (f)(i). [2]

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(Question 5, part 2 continued)

(iii) Calculate the total power dissipated in the circuit when the maximum power is being delivered to the external circuit. [3]

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6. This question is in **two** parts. **Part 1** is about momentum. **Part 2** is about electric point charges.

Part 1 Momentum

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

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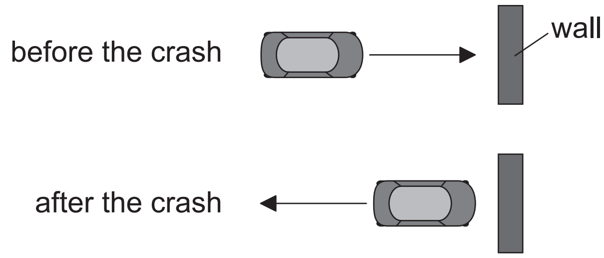
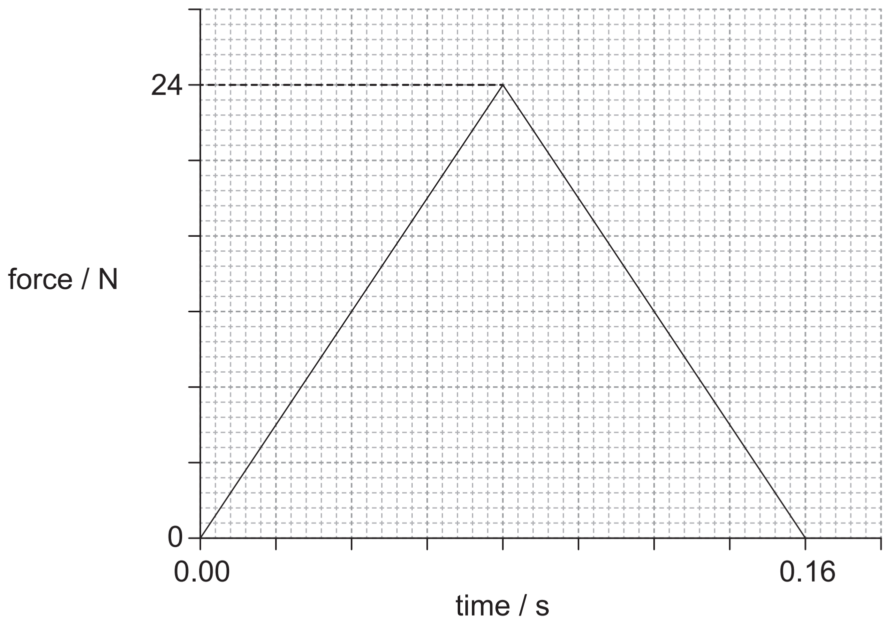
(Question 6, part 1 continued)

(b) A toy car crashes into a wall and rebounds at right angles to the wall, as shown in the plan view.



The graph shows the variation with time of the force acting on the car due to the wall during the collision.



The kinetic energy of the car is unchanged after the collision. The mass of the car is 0.80 kg.

(i) Determine the initial momentum of the car. [3]

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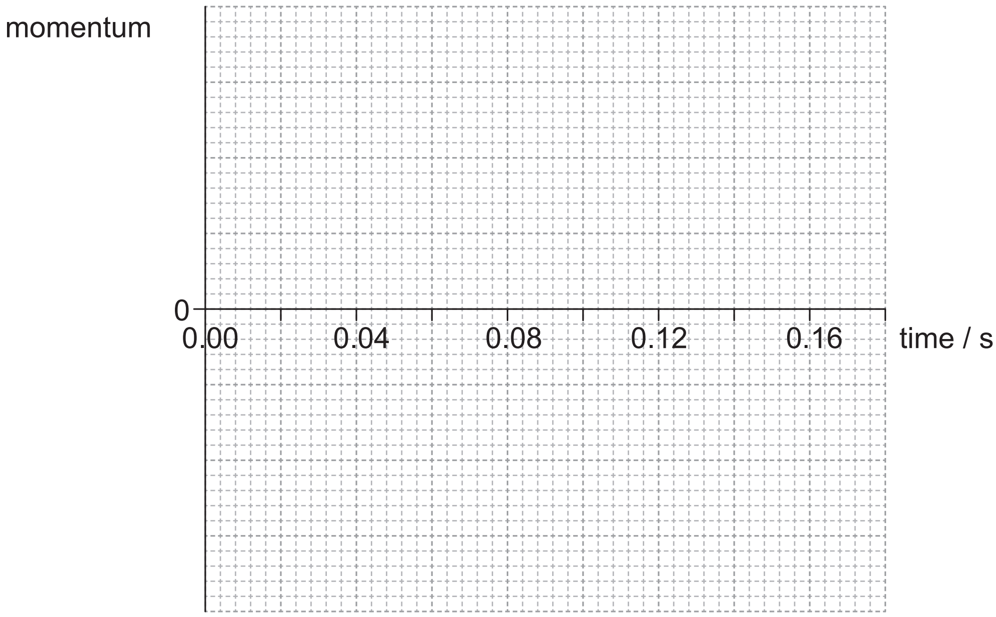
(Question 6, part 1 continued)

(ii) Estimate the average acceleration of the car before it rebounds. [3]

(iii) On the axes, draw a graph to show how the momentum of the car varies during the impact. You are not required to give values on the y-axis. [3]



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(Question 6, part 1 continued)

(c) Two identical toy cars, A and B are dropped from the same height onto a solid floor without rebounding. Car A is unprotected whilst car B is in a box with protective packaging around the toy. Explain why car B is less likely to be damaged when dropped. [4]

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Part 2 Electric point charges

(d) Define *electric field strength* at a point in an electric field. [2]

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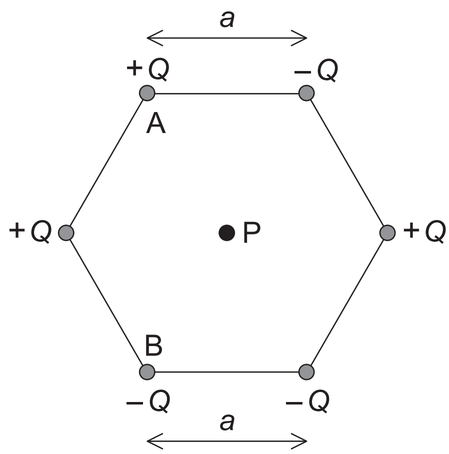
(Question 6, part 2 continued)

(e) Six point charges of equal magnitude Q are held at the corners of a hexagon with the signs of the charges as shown. Each side of the hexagon has a length a.



P is at the centre of the hexagon.

(i) Show, using Coulomb's law, that the magnitude of the electric field strength at point P due to **one** of the point charges is

$$\frac{kQ}{a^2}.$$ [2]

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(ii) On the diagram, draw arrows to represent the direction of the field at P due to point charge A (label this direction A) and point charge B (label this direction B). [2]

(This question continues on the following page)

(Question 6, part 2 continued)

(iii) The magnitude of Q is 3.2 μC and length a is 0.15 m. Determine the magnitude and the direction of the electric field strength at point P due to all six charges. [4]

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