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

N04/4/PHYSI/SP2/ENG/TZ0/XX+

88046505

PHYSICS
STANDARD LEVEL
PAPER 2

School code

Friday 5 November 2004 (afternoon)

1 hour 15 minutes

Candidate code

INSTRUCTIONS TO CANDIDATES

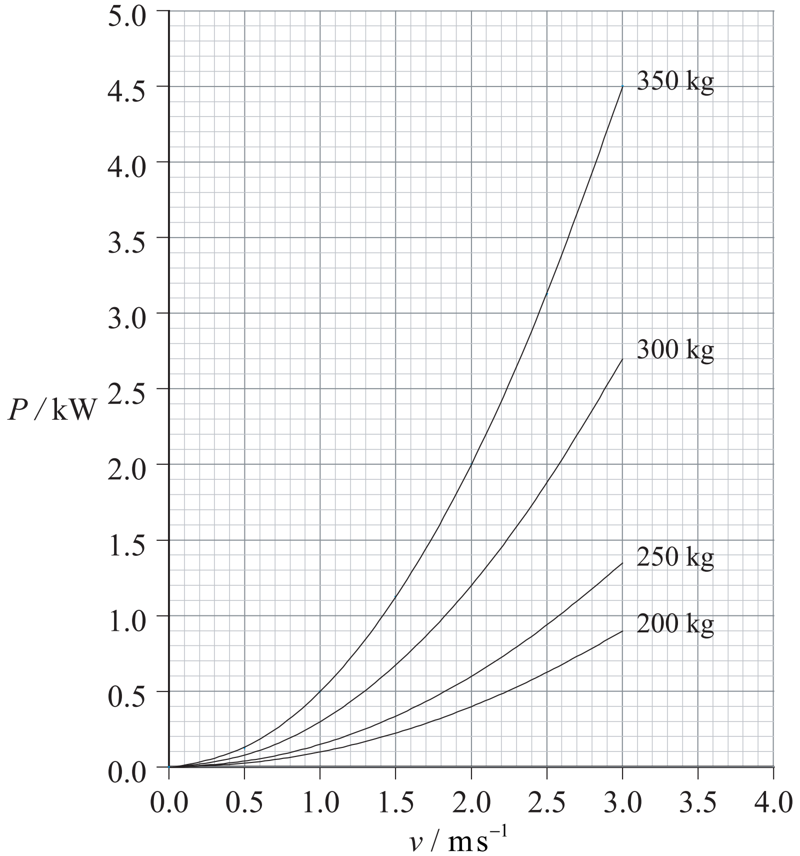
- Write your school code and candidate code in the boxes above.
- Do not open this examination paper until instructed to do so.
- Section A: answer all of Section A in the spaces provided.
- Section B: answer one question from Section B in the spaces provided.
- At the end of the examination, indicate 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 power output of an outboard motor.

A small boat is powered by an outboard motor of variable power P. The graph below shows the variation with speed v of P when the boat is carrying different loads.



The masses shown are the total mass of the boat plus passengers.

(a) For the boat having a steady speed of $2.0\,\text{m s}^{-1}$ and with a total mass of 350 kg

(i) use the graph to determine the power of the engine. *[1]*

. . . .

(ii) calculate the frictional (resistive) force acting on the boat. *[2]*

. . . .

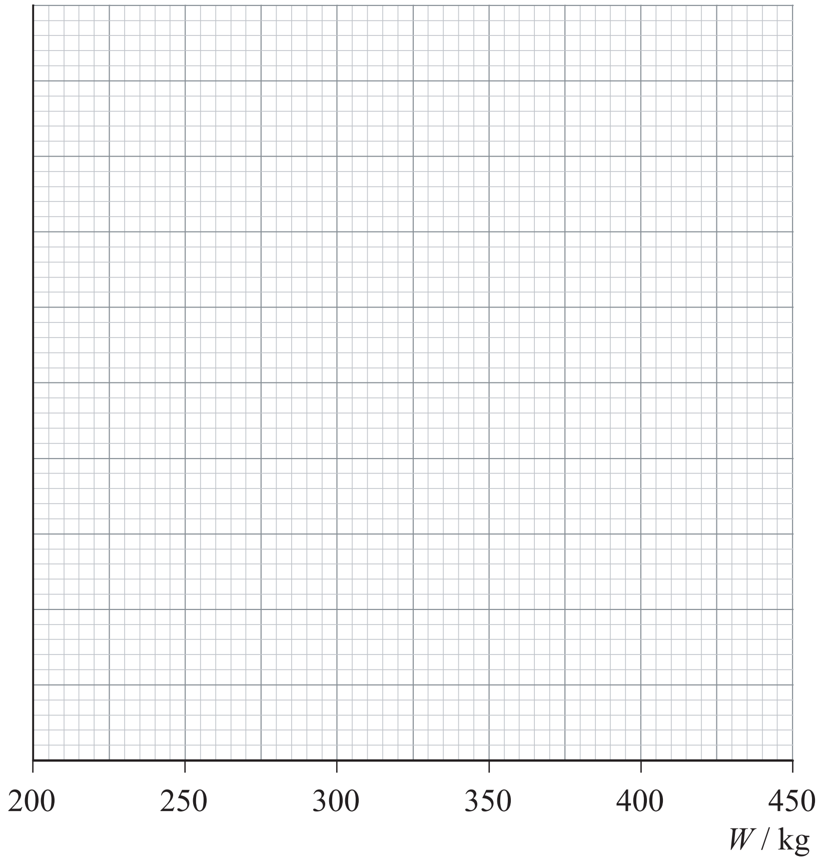
. . . .

(This question continues on the following page)

(Question A1 continued)

Consider the case of the boat moving with a speed of $2.5\,\text{m s}^{-1}$.

(b) (i) Use the axes below to construct a graph to show the variation of power P with the total mass W. *[6]*

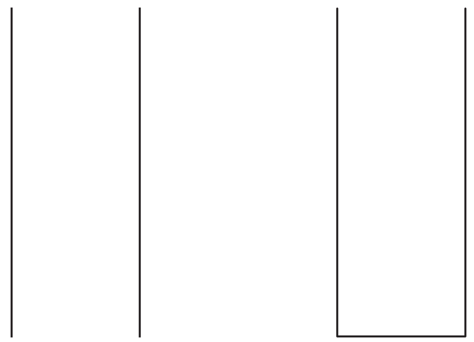


(ii) Use data from the graph that you have drawn to determine the output power of the motor for a total mass of 330 kg. *[1]*

. . . .

A2. This question is about standing waves in pipes.

The diagram below shows two pipes of the same length. Pipe A is open at both ends and pipe B is closed at one end.



(a) (i) On the diagrams above, draw lines to represent the waveforms of the fundamental (first harmonic) resonant note for each pipe. *[2]*

(ii) On each diagram, label the position of the nodes with the letter N and the position of the antinodes with the letter A. *[2]*

The frequency of the fundamental note for pipe A is 512 Hz.

(b) (i) Calculate the length of the pipe A. (Speed of sound in air = $325\,\mathrm{m\,s^{-1}}$) *[3]*

. . . .

. . . .

. . . .

. . . .

(ii) Suggest why organ pipes designed to emit low frequency fundamental notes (*e.g.* frequency ≈ 32 Hz) are often closed at one end. *[2]*

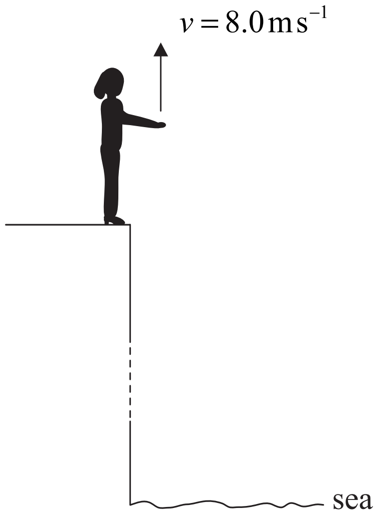
. . . .

. . . .

. . . .

A3. This question is about throwing a stone from a cliff.

Antonia stands at the edge of a vertical cliff and throws a stone vertically upwards.



The stone leaves Antonia's hand with a speed $v = 8.0\,\text{m s}^{-1}$.

The acceleration of free fall g is $10\,\text{m s}^{-2}$ and all distance measurements are taken from the point where the stone leaves Antonia's hand.

(a) Ignoring air resistance calculate

(i) the maximum height reached by the stone. *[2]*

. . . .

. . . .

. . . .

(ii) the time taken by the stone to reach its maximum height. *[1]*

. . . .

. . . .

The time between the stone leaving Antonia's hand and hitting the sea is 3.0 s.

(b) Determine the height of the cliff. *[3]*

. . . .

. . . .

. . . .

. . . .

. . . .

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 specific heat capacity and specific latent heat. **Part 2** is about radioactivity and nuclear energy.

Part 1 Specific heat capacity and specific latent heat

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

. . . .

. . . .

(b) Explain briefly why the specific heat capacity of different substances such as aluminium and water are not equal in value. *[2]*

. . . .

. . . .

. . . .

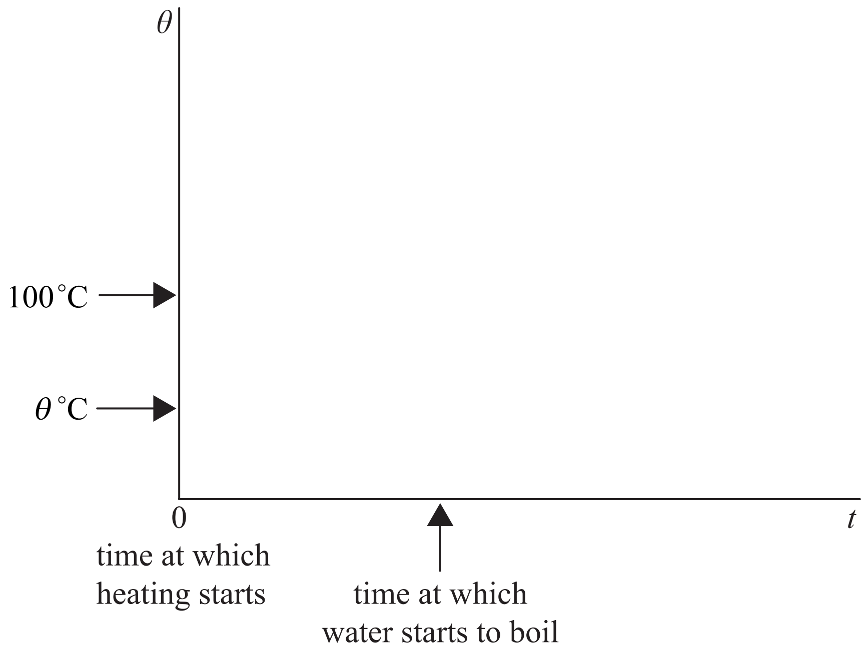
. . . .

(This question continues on the following page)

(Question B1, part 1 continued)

A quantity of water at temperature θ is placed in a pan and heated at a constant rate until some of the water has turned into steam. The boiling point of the water is 100˚C.

(c) (i) Using the axes below, draw a sketch-graph to show the variation with time t of the temperature θ of the water. *(**Note**: this is a sketch-graph; you do not need to add any values to the axes.)* *[1]*



(ii) Describe in terms of energy changes, the molecular behaviour of water and steam during the heating process. *[5]*

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

(This question continues on the following page)

(Question B1, part 1 continued)

Thermal energy is supplied to the water in the pan for 10 minutes at a constant rate of 400 W. The thermal capacity of the pan is negligible.

(d) (i) Deduce that the total energy supplied in 10 minutes is 2.4×10^{5} J. *[1]*

. . . .

(ii) Using the data below, estimate the mass of water turned into steam as a result of this heating process. *[3]*

initial mass of water	$= 0.30\,\text{kg}$
initial temperature of the water θ	$= 20\,^{\circ}\text{C}$
specific heat capacity of water	$= 4.2\times10^{3}\,\text{J kg}^{-1}\,\text{K}^{-1}$
specific latent heat of vaporization of water	$= 2.3\times10^{6}\,\text{J kg}^{-1}$

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

(iii) Suggest **one** reason why this mass is an estimate. *[1]*

. . . .

. . . .

(This question continues on the following page)

(Question B1 continued)

Part 2 Radioactivity and nuclear energy

(a) Define the following terms.

(i) *Isotope* *[1]*

. . . .

. . . .

(ii) *Radioactive half-life* *[1]*

. . . .

. . . .

(This question continues on the following page)

(Question B1, part 2 continued)

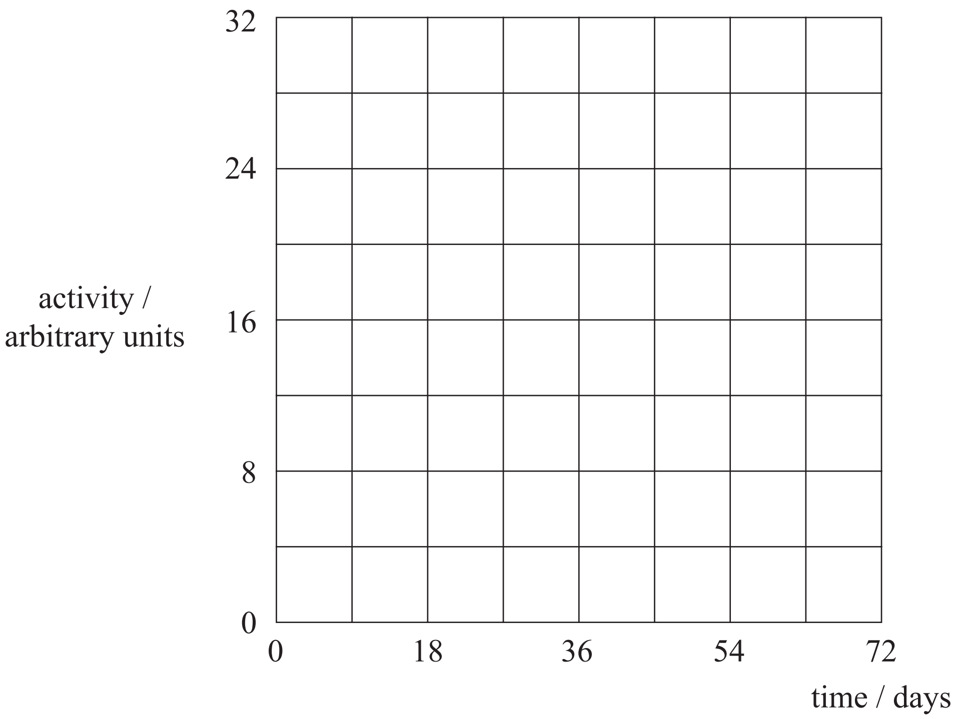
Thorium-227 (Th-227) results from the decay of the isotope actinium-227.

(b) (i) Complete the following reaction equation. *[1]*

$$^{227}_{89}\text{Ac} \rightarrow {}^{227}_{90}\text{Th} +$$

Th-227 has a half-life of 18 days and undergoes α-decay to the isotope Ra-223 (Ra-223). A sample of Th-227 has an initial activity of 32 arbitrary units.

(ii) Using the axes below, draw a graph to show the variation with time t (for $t = 0$ to $t = 72$ days) of the activity A of Th-227. *[2]*



(iii) Determine from your graph, the activity of thorium after 50 days. *[1]*

. . . .

(iv) Outline the experimental procedure to measure the activity of Th-227. *[2]*

. . . .

. . . .

. . . .

. . . .

(This question continues on the following page)

(Question B1, part 2 continued)

In the decay of a Th-227 nucleus, a γ-ray photon is also emitted.

(c) Use the following data to deduce that the energy of the γ-ray photon is 0.667 MeV. *[3]*

mass of Th-227 nucleus	= 227.0278 u
mass of Ra-223 nucleus	= 223.0186 u
mass of helium nucleus	= 4.0026 u
energy of α-particle emitted	= 5.481 MeV
unified atomic mass unit (u)	= 931.5 MeV c^{-2}

You may assume that the Th-227 nucleus is stationary before decay and that the Ra-223 nucleus has negligible kinetic energy.

. . . .

. . . .

. . . .

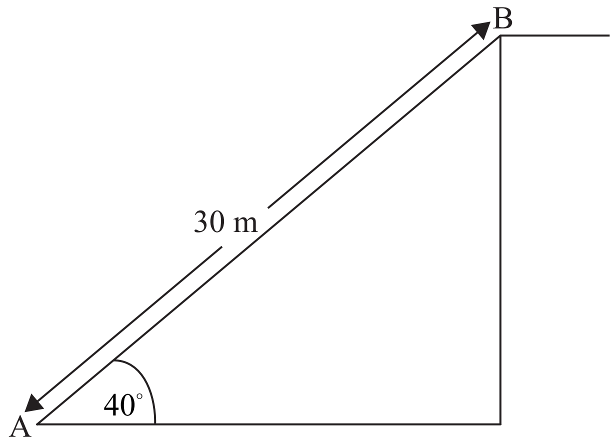
. . . .

. . . .

B2. This question is in **two** parts. **Part 1** is about estimating energy changes for an escalator (moving staircase). **Part 2** is about electric circuits.

Part 1 Estimating energy changes for an escalator

The diagram below represents an escalator. People step on to it at point A and step off at point B.



(a) The escalator is 30 m long and makes an angle of 40° with the horizontal. At full capacity, 48 people step on at point A and step off at point B every minute.

(i) Calculate the potential energy gained by a person of weight 7.0×10^2 N in moving from A to B. *[2]*

. . . .

. . . .

. . . .

(ii) Estimate the energy supplied by the escalator motor to the people every minute when the escalator is working at full capacity. *[1]*

. . . .

. . . .

(iii) State **one** assumption that you have made to obtain your answer to (ii). *[1]*

. . . .

. . . .

(This question continues on the following page)

(Question B2, part 1 continued)

The escalator is driven by an electric motor that has an efficiency of 70 %.

(b) Using your answer to (a) (ii), calculate the minimum input power required by the motor to drive the escalator. *[3]*

. . . .

. . . .

. . . .

. . . .

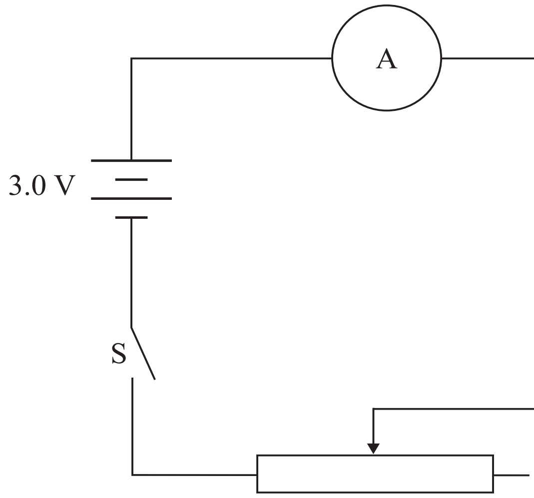
(Question B2 continues on page 15)

Blank page

(Question B2 continued)

Part 2 Electric circuits

Susan sets up the circuit below in order to measure the current-voltage (*I-V*) characteristic of a small filament lamp.



The supply is a battery that has an e.m.f. of 3.0 V and the ammeter and voltmeter are considered to be ideal. The lamp is labelled by the manufacturer as "3 Volts, 0.6 Watts".

(a) (i) Explain what information this labelling provides about the normal operation of the lamp. *[2]*

. . . .

. . . .

. . . .

. . . .

. . . .

(ii) Calculate the current in the filament of the lamp when it is operating at normal brightness. *[2]*

. . . .

. . . .

. . . .

. . . .

. . . .

(This question continues on the following page)

(Question B2, part 2 continued)

Susan sets the variable resistor to its maximum value of resistance. She then closes the switch S and records the following readings.

Ammeter reading = 0.18 A	Voltmeter reading = 0.60 V

She then sets the variable resistor to its zero value of resistance and records the following readings.

Ammeter reading = 0.20 A	Voltmeter reading = 2.6 V

(b) (i) Explain why, by changing the value of the resistance of the variable resistance, the potential difference across the lamp cannot be reduced to zero or be increased to 3.0 V. *[2]*

. . . .

. . . .

. . . .

. . . .

(ii) Determine the internal resistance of the battery. *[3]*

. . . .

. . . .

. . . .

. . . .

(This question continues on the following page)

(Question B2, part 2 continued)

(c) Calculate the resistance of the filament when the reading on the voltmeter is

(i) 0.60 V. *[1]*

. . . .

. . . .

(ii) 2.6 V. *[1]*

. . . .

. . . .

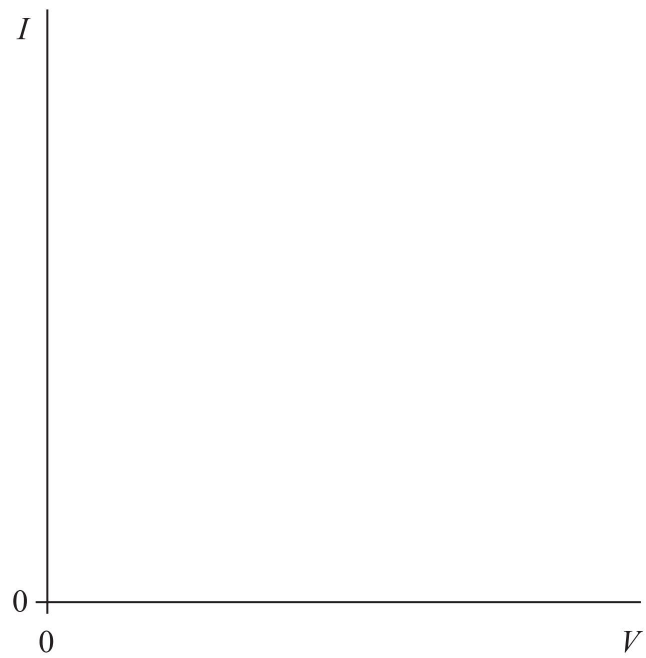
(d) Explain why there is a difference between your answers to (c) (i) and (c) (ii). *[2]*

. . . .

. . . .

. . . .

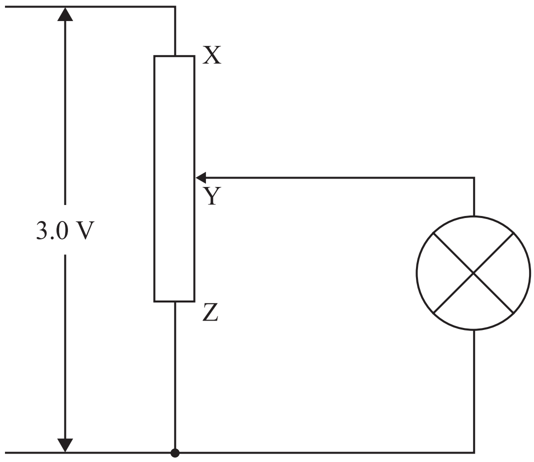
(e) Using the axes below, draw a sketch-graph of the *I*-*V* characteristic of the filament of the lamp. *(**Note**: this is a sketch-graph; you do not need to add any values to the axis.)* *[1]*



(This question continues on the following page)

(Question B2, part 2 continued)

The diagram below shows an alternative circuit for varying the potential difference across the lamp.



The potential divider XZ has a potential of 3.0 V across it. When the contact is at the position Y, the resistance of XY equals the resistance of YZ which equals 12 Ω. The resistance of the lamp is 4.0 Ω.

(f) Calculate the potential difference across the lamp. *[4]*

. . . .

. . . .

. . . .

. . . .

. . . .

Blank page

B3. This question is in **two** parts. **Part 1** is about conservation of momentum and conservation of energy. **Part 2** is about electric charge at rest.

Part 1 Conservation of momentum and energy

(a) State Newton's third law. *[1]*

. . . .

. . . .

. . . .

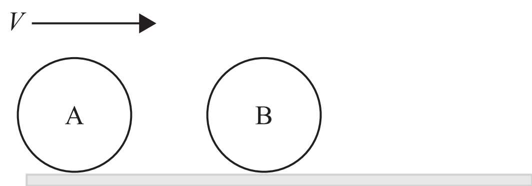
(b) State the law of conservation of momentum. *[2]*

. . . .

. . . .

The diagram below shows two identical balls A and B on a horizontal surface. Ball B is at rest and ball A is moving with speed V along a line joining the centres of the balls. The mass of each ball is M.

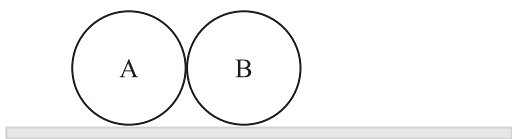
Before collision



During the collision of the balls, the magnitude of the force that ball A exerts on ball B is F_{AB} and the magnitude of the force that ball B exerts on ball A is F_{BA}.

(c) On the diagram below, add labelled arrows to represent the magnitude and direction of the forces F_{AB} and F_{BA}. *[3]*

During the collision

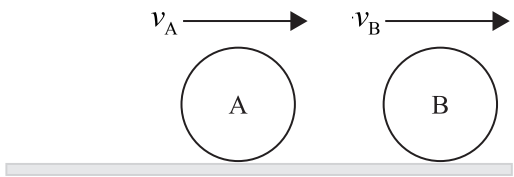


(This question continues on the following page)

(Question B3, part 1 continued)

The balls are in contact for a time Δt. After the collision, the speed of ball A is $+v_A$ and the speed of ball B is $+v_B$ in the directions shown.

After the collision



As a result of the collision, there is a change in momentum of ball A and of ball B.

(d) Use Newton's second law of motion to deduce an expression relating the forces acting during the collision to the change in momentum of

(i) ball B. *[2]*

. . . .

. . . .

(ii) ball A. *[2]*

. . . .

. . . .

(e) Apply Newton's third law and your answers to (d), to deduce that the change in momentum of the system (ball A and ball B) as a result of this collision, is zero. *[4]*

. . . .

. . . .

. . . .

. . . .

. . . .

(f) Deduce, that if kinetic energy is conserved in the collision, then after the collison, ball A will come to rest and ball B will move with speed V. *[3]*

. . . .

. . . .

. . . .

. . . .

. . . .

(This question continues on the following page)

(Question B3 continued)

Part 2 Electric charge at rest

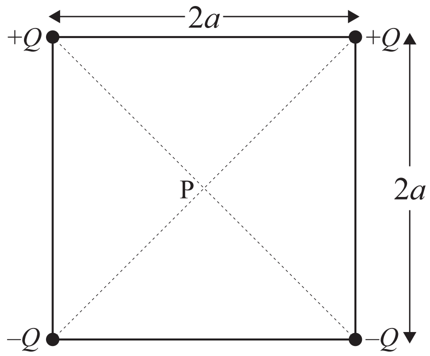
(a) Define *electric field strength* at a point in an electric field. *[2]*

. . . .

. . . .

. . . .

Four point charges of equal magnitude, are held at the corners of a square as shown below.



The length of each side of the square is $2a$ and the sign of the charges is as shown. The point P is at the centre of the square.

(b) (i) Deduce that the magnitude of the electric field strength at point P due to one of the point charges is equal to $\dfrac{kQ}{2a^2}$. *[2]*

. . . .

. . . .

(ii) On the diagram above, draw an arrow to represent the direction of the resultant electric field at point P. *[1]*

(iii) Determine in terms of Q, a and k, the magnitude of the electric field strength at point P. *[3]*

. . . .

. . . .

. . . .

. . . .

. . . .