Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

General Certificate of Education
Advanced Level Examination
January 2013

Physics A PHYA4/1

Unit 4 Fields and Further Mechanics
Section A

Wednesday 16 January 2013 1.30 pm to 3.15 pm

In addition to this paper you will require:
- an objective test answer sheet
- a black ink or black ball-point pen
- a calculator
- a question paper/answer book for Section B (enclosed)
- a Data and Formulae booklet.

Time allowed
- The total time for both sections of this paper is 1 hour 45 minutes. You are advised to spend approximately 45 minutes on this section.

Instructions
- Use black ink or black ball-point pen. Do **not** use pencil.
- Answer **all** questions in this section.
- For each question there are four responses. When you have selected the response which you think is the most appropriate answer to a question, mark this response on your answer sheet.
- Mark all responses as instructed on your answer sheet. If you wish to change your answer to a question, follow the instructions on your answer sheet.
- Do all rough work in this book **not** on the answer sheet.

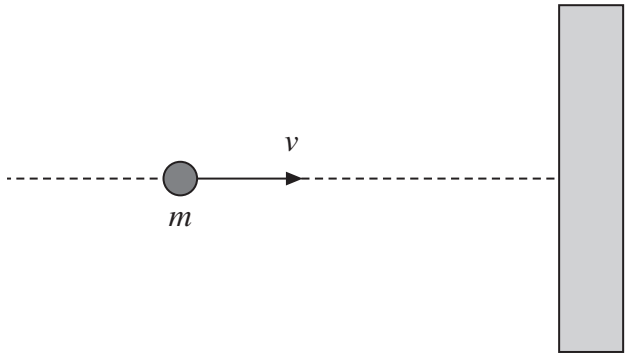
Information
- The maximum mark for this section is 25.
- All questions in Section A carry equal marks. No deductions will be made for incorrect answers.
- A *Data and Formulae Booklet* is provided as a loose insert.
- The question paper/answer book for Section B is enclosed within this question paper.

Multiple choice questions

Each of Questions **1** to **25** is followed by four responses, **A**, **B**, **C**, and **D**. For each question select the best response and mark its letter on the answer sheet.

You are advised to spend approximately **45 minutes** on this section.

1 A ball of mass m travelling at velocity v collides normally with a smooth wall, as shown in the diagram, and rebounds elastically.



Which line, **A** to **D**, in the table, gives the correct expressions for the magnitude of the change of momentum, and the change of kinetic energy, of the ball?

	magnitude of change of momentum	**change of kinetic energy**
A	$2mv$	0
B	$2mv$	mv^2
C	0	0
D	0	mv^2

2 A cricket ball of mass 0.16 kg travelling at a speed of 35 m s^{-1} is hit by a bat and, as a result of the impact, leaves the bat in the opposite direction at 30 m s^{-1}. If the duration of the impact is 52 ms, what is the magnitude of the average force on the ball?

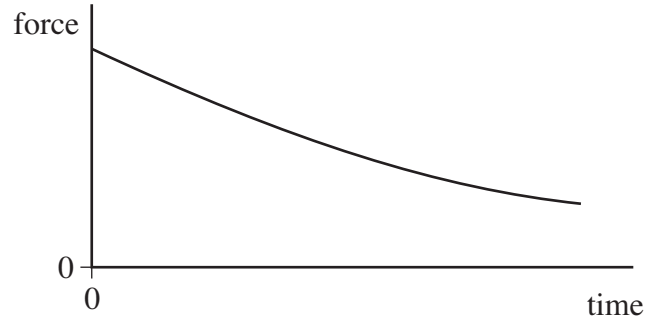
A 0.015 N

B 0.20 N

C 15 N

D 200 N

3 A ball is released so that it falls vertically. The graph shows how the resultant force acting on the ball changes with time.



Which one of the following is represented by the area under the graph?

A distance travelled

B gain in kinetic energy

C acceleration

D impulse

4 For a particle moving in a circle with uniform speed, which one of the following statements is **incorrect**?

A There is no displacement of the particle in the direction of the force.

B The force on the particle is always perpendicular to the velocity of the particle.

C The velocity of the particle is constant.

D The kinetic energy of the particle is constant.

5 A revolving mountain top restaurant turns slowly, completing a full rotation in 50 minutes. A man is sitting in the restaurant 15 m from the axis of rotation. What is the speed of the man relative to a stationary point outside the restaurant?

A $\frac{\pi}{100}\ \text{m s}^{-1}$

B $\frac{3\pi}{5}\ \text{m s}^{-1}$

C $\frac{\pi}{200}\ \text{m s}^{-1}$

D $\frac{\pi}{1500}\ \text{m s}^{-1}$

6 A particle of mass 0.20 kg moves with simple harmonic motion of amplitude 2.0×10^{-2} m. If the total energy of the particle is 4.0×10^{-5} J, what is the time period of the motion?

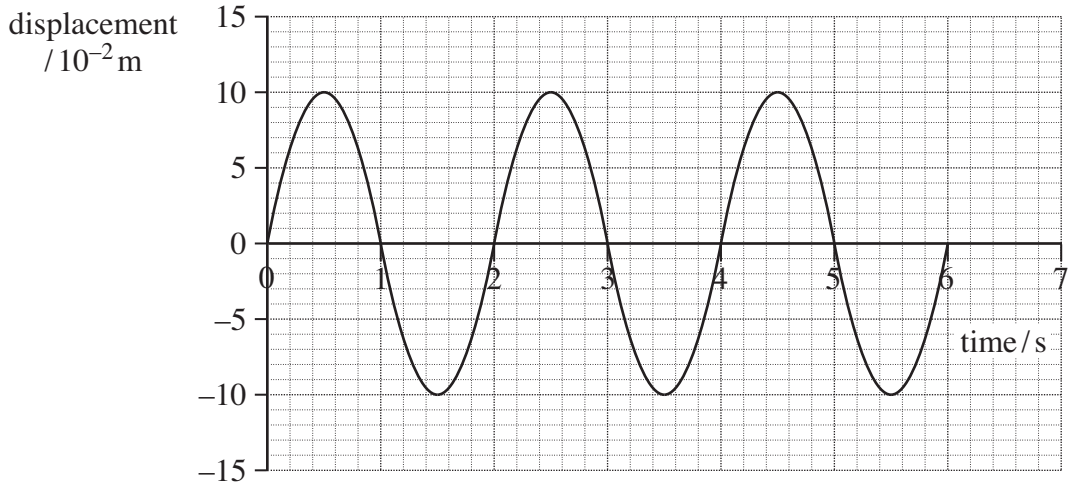
A $\frac{\pi}{4}$ seconds

B $\frac{\pi}{2}$ seconds

C π seconds

D 2π seconds

7 The graph shows the variation in displacement with time for an object moving with simple harmonic motion.



What is the maximum acceleration of the object?

A 0.025 m s^{-2}

B 0.99 m s^{-2}

C 2.5 m s^{-2}

D 9.8 m s^{-2}

8 A simple pendulum and a mass-spring system are taken to the Moon, where the gravitational field strength is less than on Earth. Which line, **A** to **D**, in the table correctly describes the change, if any, in the period when compared with its value on Earth?

	period of pendulum	**period of mass-spring system**
A	increase	no change
B	increase	increase
C	no change	decrease
D	decrease	decrease

9 Two pendulums, P and Q, are set up alongside each other. The period of P is 1.90 s and the period of Q is 1.95 s.

How many oscillations are made by pendulum Q between two consecutive instants when P and Q move in phase with each other?

A 19
B 38
C 39
D 78

10 A small mass is situated at a point on a line joining two large masses m_1 and m_2 such that it experiences no resultant gravitational force. Its distance from the centre of mass of m_1 is r_1 and its distance from the centre of mass of m_2 is r_2.

What is the value of the ratio $\frac{r_1}{r_2}$?

A $\frac{{m_1}^2}{{m_2}^2}$

B $\frac{{m_2}^2}{{m_1}^2}$

C $\sqrt{\frac{m_1}{m_2}}$

D $\sqrt{\frac{m_2}{m_1}}$

11 Which one of the following gives a correct unit for $\left(\frac{g^2}{G}\right)$?

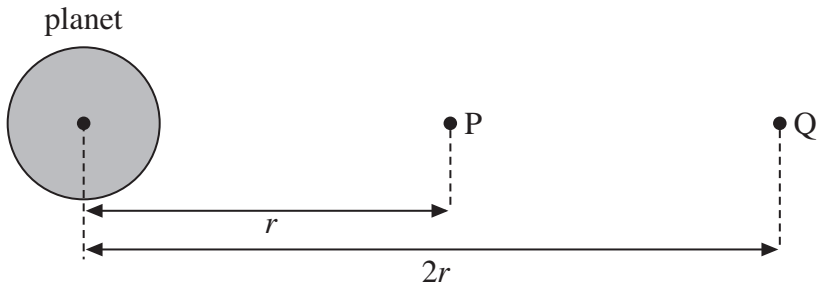
A $\mathrm{N\,m^{-2}}$
B $\mathrm{N\,kg^{-1}}$
C $\mathrm{N\,m}$
D N

12 The gravitational field strength at the surface of the Earth is 6 times its value at the surface of the Moon. The mean density of the Moon is 0.6 times the mean density of the Earth.

What is the value of the ratio $\left(\frac{\text{radius of Earth}}{\text{radius of Moon}}\right)$?

A 1.8
B 3.6
C 6.0
D 10

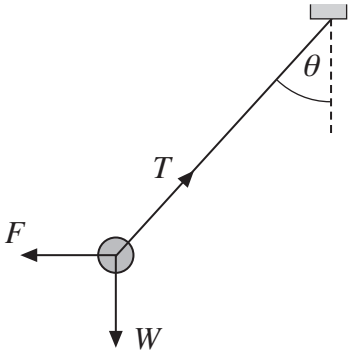
13 The diagram shows two points, P and Q, at distances r and $2r$ from the centre of a planet.



The gravitational potential at P is $-16\,\text{kJ kg}^{-1}$. What is the work done on a 10 kg mass when it is taken from P to Q?

A $-120\,\text{kJ}$
B $-80\,\text{kJ}$
C $+80\,\text{kJ}$
D $+120\,\text{kJ}$

14 A small sphere, of mass m and carrying a charge Q, is suspended from a thread and placed in a uniform horizontal electric field of strength E. When the sphere comes to rest the thread makes an angle θ with the vertical and the tension in it is T, as shown in the diagram. W is the weight of the sphere and F is the electric force acting on it.



Under these conditions, which one of the following equations is **incorrect**?

A $T \sin \theta = EQ$

B $T = mg\cos\theta + EQ\sin\theta$

C $T^2 = (EQ)^2 + (mg)^2$

D $mg = EQ\tan\theta$

15 When a charge moves between two points in an electric field, or a mass moves between two points in a gravitational field, energy may be transferred.
Which one of the following statements is correct?

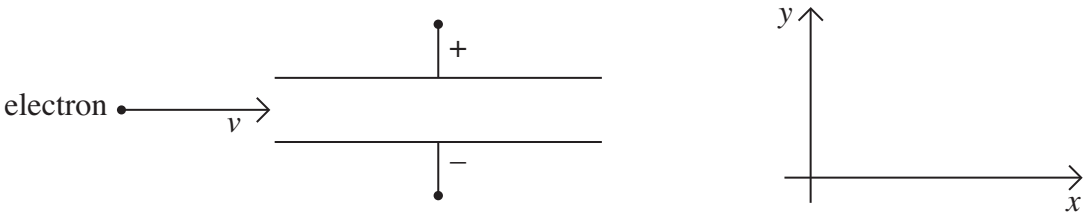
A No energy is transferred when the movement is parallel to the direction of the field.

B The energy transferred is independent of the path followed.

C The energy transferred is independent of the start and finish points.

D Energy is transferred when the movement is perpendicular to the field lines.

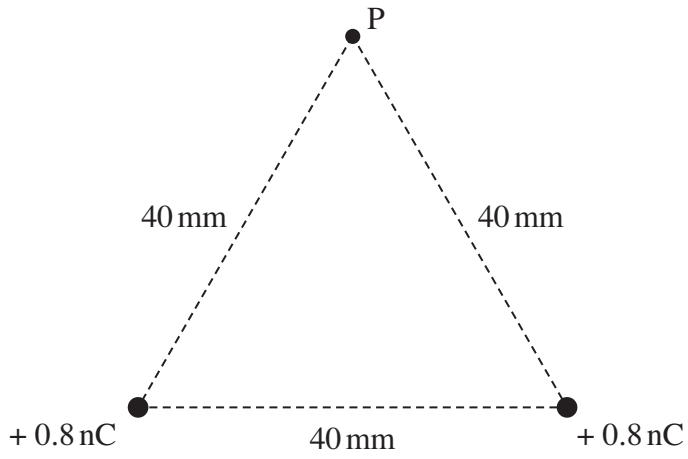
16 A beam of electrons, moving with a constant velocity v in a vacuum, enters a uniform electric field between two metal plates.



Which line, **A** to **D**, in the table describes the components of the acceleration of the electrons in the x and y directions as they move through the field?

	acceleration in *x* direction	**acceleration in *y* direction**
A	zero	zero
B	zero	constant
C	constant	zero
D	constant	constant

17 Two charges, each of +0.8 nC, are 40 mm apart.
Point P is 40 mm from each of the charges.



What is the electric potential at P?

A zero

B 180 V

C 360 V

D 4500 V

18 An initially uncharged capacitor of capacitance 20 μF is charged by a constant current of 80 μA. Which line, **A** to **D**, in the table gives the potential difference across, and the energy stored in, the capacitor after 50 s?

	potential difference / V	**energy stored / J**
A	4.0×10^{-3}	2.0×10^{-3}
B	4.0×10^{-3}	4.0×10^{-1}
C	2.0×10^{2}	2.0×10^{-3}
D	2.0×10^{2}	4.0×10^{-1}

19 Which one of the following statements about a parallel plate capacitor is **incorrect**?

A The capacitance of the capacitor is the amount of charge stored by the capacitor when the pd across the plates is 1 V.

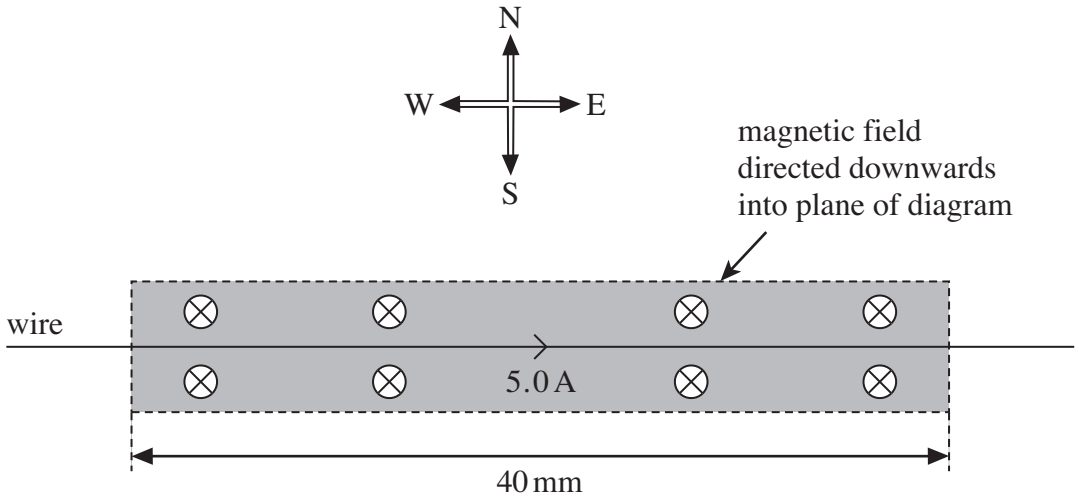
B A uniform electric field exists between the plates of the capacitor.

C The charge stored on the capacitor is inversely proportional to the pd across the plates.

D The energy stored when the capacitor is fully charged is proportional to the square of the pd across the plates.

Turn over for the next question

20 A horizontal straight wire of length 40 mm is in an east-west direction as shown in the diagram. A uniform magnetic field of flux density 50 mT is directed downwards into the plane of the diagram.



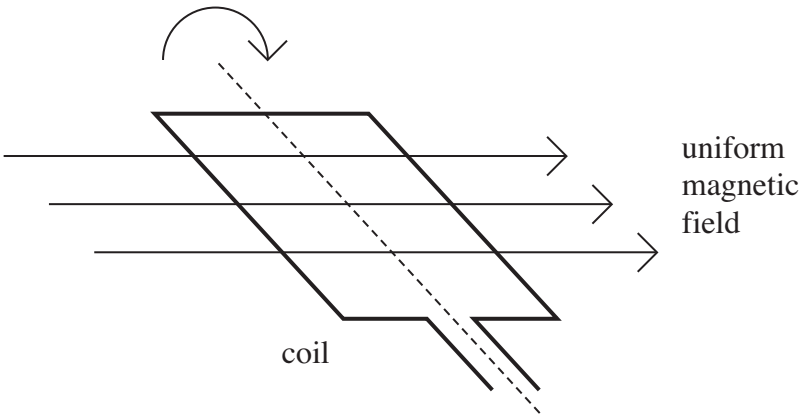
When a current of 5.0 A passes through the wire from west to east, a horizontal force acts on the wire. Which line, **A** to **D**, in the table gives the magnitude and direction of this force?

	magnitude / mN	**direction**
A	2.0	north
B	10.0	north
C	2.0	south
D	10.0	south

21 Which line, **A** to **D**, in the table correctly describes the trajectory of charged particles which enter separately, at right angles, a uniform electric field, and a uniform magnetic field?

	uniform electric field	**uniform magnetic field**
A	parabolic	circular
B	circular	parabolic
C	circular	circular
D	parabolic	parabolic

22 A rectangular coil is rotated in a uniform magnetic field.



When the coil is rotated at a constant rate, an alternating emf ε is induced in it. The variation of emf ε, in volts, with time t, in seconds, is given by

$$\varepsilon = 20 \sin (100 \pi t)$$

Which line, **A** to **D**, in the table gives the peak value ε_0 and the frequency f of the induced emf?

	ε_0 / V	f / Hz
A	10	50
B	10	100
C	20	50
D	20	100

23 The magnetic flux through a coil of 5 turns changes uniformly from 15×10^{-3} Wb to 7.0×10^{-3} Wb in 0.50 s. What is the magnitude of the emf induced in the coil due to this change in flux?

A 14 mV

B 16 mV

C 30 mV

D 80 mV

24 Which one of the following statements concerning power losses in a transformer is **incorrect**?

Power losses can be reduced by

A laminating the core.

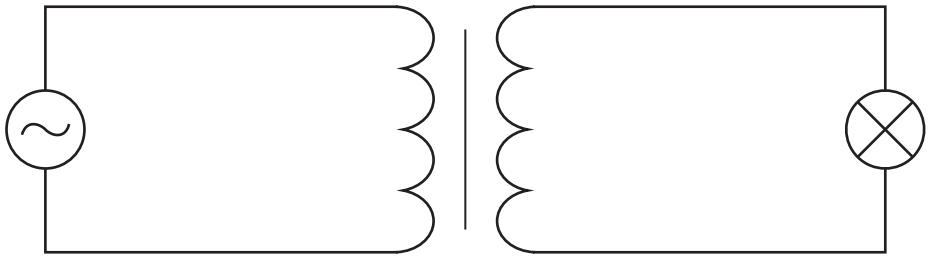
B using high resistance windings.

C using thick wire.

D using a core made of special iron alloys which are easily magnetised.

25 A transformer with 3000 turns in its primary coil is used to change an alternating pd from an rms value of 240 V to an rms value of 12 V.

When a 60 W, 12 V lamp is connected to the secondary coil, the lamp lights at normal brightness and a rms current of 0.26 A passes through the primary coil.



Which line, **A** to **D**, in the table gives correct values for the number of turns on the secondary coil and for the transformer efficiency?

	number of turns on the secondary coil	**efficiency**
A	150	96%
B	60 000	96%
C	150	90%
D	60 000	90%

END OF QUESTIONS

Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
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4	
5	
TOTAL	

General Certificate of Education
Advanced Level Examination
January 2013

Physics A PHYA4/2

Unit 4 Fields and Further Mechanics
Section B

Wednesday 16 January 2013 1.30 pm to 3.15 pm

For this paper you must have:
- a calculator
- a ruler
- a Data and Formulae Booklet (enclosed).

Time allowed
- The total time for both sections of this paper is 1 hour 45 minutes. You are advised to spend approximately one hour on this section.

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Answers written in margins or on blank pages will not be marked.
- Do all rough work in this book. Cross through any work you do not want to be marked
- Show all your working.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this section is 50.
- You are expected to use a calculator where appropriate.
- A *Data and Formulae Booklet* is provided as a loose insert.
- You will be marked on your ability to:
  – use good English
  – organise information clearly
  – use specialist vocabulary where appropriate.

Answer **all** questions in the spaces provided.
You are advised to spend approximately **one hour** on this section.

1 (a) State **one** similarity and **one** difference between an elastic collision and an inelastic collision.

similarity .....

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difference .....

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(2 marks)

1 (b) An unstable isotope of neodymium, $^{144}_{60}\text{Nd}$, decays into an isotope of cerium, Ce, by emitting an α particle.

1 (b) (i) Complete the following decay equation.

$$^{144}_{60}\text{Nd} \rightarrow {}^{\cdots\cdots}_{\cdots\cdots}\text{Ce} + {}^{\cdots\cdots}_{\cdots\cdots}\alpha$$

(1 mark)

1 (b) (ii) The α particle is emitted from a stationary $^{144}_{60}\text{Nd}$ nucleus at a speed of $9.3 \times 10^6\,\text{m s}^{-1}$. Calculate the recoil speed of the daughter nucleus.

recoil speed ..... m s^{-1}

(2 marks)

1 (b) (iii) Show that, when a stationary $^{144}_{60}$Nd nucleus decays, the kinetic energy of the recoiling cerium nucleus is only about 3% of the kinetic energy of the emitted α particle.

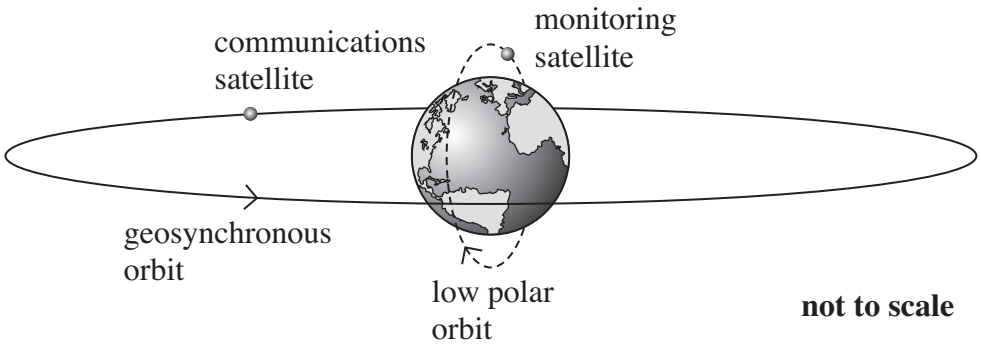
(3 marks)

8

Turn over for the next question

2 **Figure 1** shows the orbits of two Earth satellites, a communications satellite in a geosynchronous orbit and a monitoring satellite in a low orbit that passes over the poles.

Figure 1



2 (a) The time period, T, of any satellite in a circular orbit around a planet is proportional to $r^{3/2}$, where r is the radius of its orbit measured from the centre of the planet.
For a satellite in a low orbit that passes over the poles of the Earth, T is 105 minutes when r is 7370 km.

2 (a) (i) Calculate the height above the surface of the Earth, in km, of a satellite in a geosynchronous circular orbit.
Give your answer to an appropriate number of significant figures.

height above surface ..... km
(4 marks)

2 (a) (ii) Calculate the centripetal force acting on the polar orbiting satellite if its mass is 650 kg.

centripetal force ..... N
(2 marks)

2 (b) These geosynchronous and polar satellites have different applications because of their different orbits in relation to the rotation of the Earth.

Compare the principal features of the geosynchronous and polar orbits and explain the consequences for possible uses of satellites in these orbits.

In your answer you should explain why:

- a low polar orbit is suitable for a satellite used to monitor conditions on the Earth.
- a geosynchronous circular orbit above the Equator is especially suitable for a satellite used in communications.

The quality of your written communication will be assessed in your answer.

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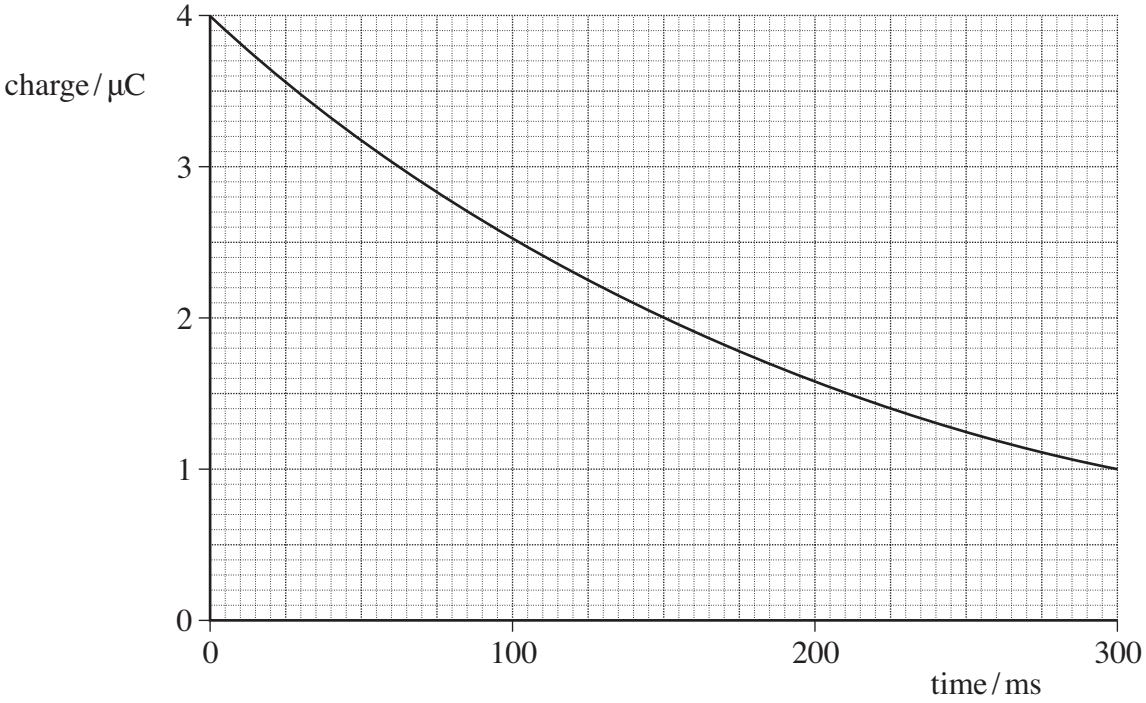
(6 marks)

12

3 **Figure 2** shows how the charge stored by a capacitor varies with time when it is discharged through a fixed resistor.

Figure 2



3 (a) Determine the time constant, in ms, of the discharge circuit.

time constant ..... ms

(3 marks)

3 (b) Explain why the rate of discharge will be greater if the fixed resistor has a smaller resistance.

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(2 marks)

5

4 (a) State, in words, Coulomb's law.

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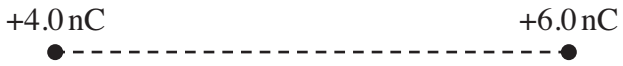
(2 marks)

4 (b) **Figure 3** shows two point charges of +4.0 nC and +6.0 nC which are 68 mm apart.

Figure 3



4 (b) (i) Sketch on **Figure 3** the pattern of the electric field surrounding the charges.

(3 marks)

4 (b) (ii) Calculate the magnitude of the electrostatic force acting on the +4.0 nC charge.

magnitude of force ..... N

(2 marks)

4 (c) (i) Calculate the magnitude of the resultant electric field strength at the mid-point of the line joining the two charges in **Figure 3**.
State an appropriate unit for your answer.

electric field strength ..... unit .....
(4 marks)

4 (c) (ii) State the direction of the resultant electric field at the mid-point of the line joining the charges.

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(1 mark)

12

Turn over for the next question

5 (a) State Lenz's law.

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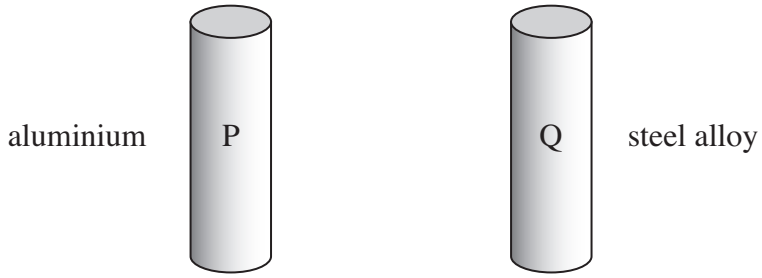
(2 marks)

5 (b) **Figure 4** shows two small, solid metal cylinders, **P** and **Q**.
P is made from aluminium. **Q** is made from a steel alloy.

Figure 4



5 (b) (i) The dimensions of **P** and **Q** are identical but **Q** has a greater mass than **P**. Explain what material property is responsible for this difference.

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(1 mark)

5 (b) (ii) When **P** and **Q** are released from rest and allowed to fall freely through a vertical distance of 1.0 m, they each take 0.45 s to do so. Justify this time value and explain why the times are the same.

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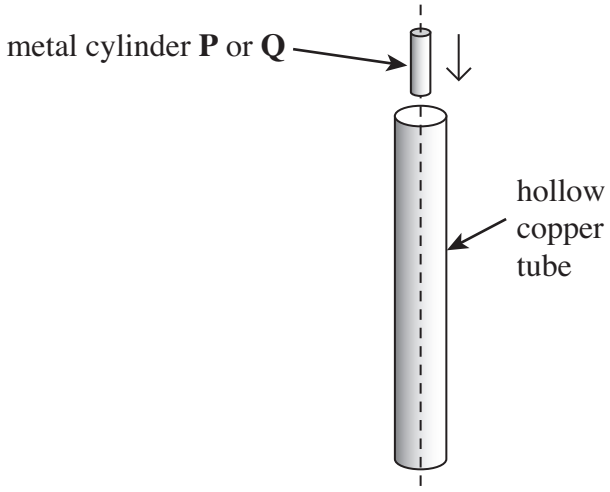
(2 marks)

5 (c) The steel cylinder **Q** is a strong permanent magnet. **P** and **Q** are released separately from the top of a long, vertical copper tube so that they pass down the centre of the tube, as shown in **Figure 5**.

Figure 5



The time taken for **Q** to pass through the tube is much longer than that taken by **P**.

5 (c) (i) Explain why you would expect an emf to be induced in the tube as **Q** passes through it.

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(2 marks)

5 (c) (ii) State the consequences of this induced emf, and hence explain why **Q** takes longer than **P** to pass through the tube.

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(3 marks)

5 (d) The copper tube is replaced by a tube of the same dimensions made from brass. The resistivity of brass is much greater than that of copper. Describe and explain how, if at all, the times taken by **P** and **Q** to pass through the tube would be affected.

P: .....

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Q: .....

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(3 marks)

13

END OF QUESTIONS