AQA

General Certificate of Education
Advanced Level Examination
June 2011

Physics A   PHYA4/1

Unit 4   Fields and Further Mechanics
Section A

Tuesday 21 June 2011   9.00 am to 10.45 am

In addition to this paper you will require:
- an objective test answer sheet
- a 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 a black ball-point pen.
- 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.

**PHYA4/1**

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 about **45 minutes** on this section.

1 Which line, **A** to **D**, in the table shows correctly whether the moment of a force, and momentum, are scalar or vector quantities?

	moment of force	momentum
A	scalar	scalar
B	scalar	vector
C	vector	scalar
D	vector	vector

2 The graph shows how the resultant force applied to an object of mass 2.0 kg, initially at rest, varies with time.
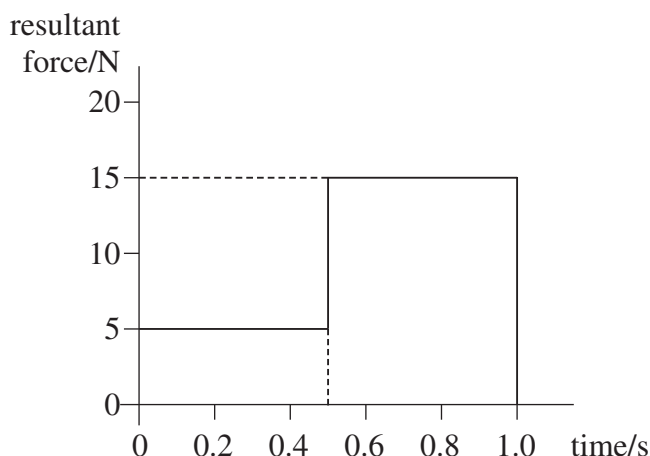
What is the speed of the object after 1.0 s?
A $2.5 \, \text{m s}^{-1}$
B $5.0 \, \text{m s}^{-1}$
C $7.5 \, \text{m s}^{-1}$
D $10 \, \text{m s}^{-1}$

3 Which of the following is a possible unit for rate of change of momentum?
A N s
B N s^{-1}
C kg m s^{-1}
D kg m s^{-2}

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

   A   The kinetic energy of the particle is constant.
   B   The force on the particle is in the same direction as the direction of motion of the particle.
   C   The momentum of the particle is constant.
   D   The displacement of the particle is in the direction of the force.

5   A young child of mass $20\,\text{kg}$ stands at the centre of a uniform horizontal platform which rotates at a constant angular speed of $3.0\,\text{rad s}^{-1}$. The child begins to walk radially outwards towards the edge of the platform. The maximum frictional force between the child and the platform is $200\,\text{N}$. What is the maximum distance from the centre of the platform to which the child could walk without the risk of slipping?

   A $1.1\,\text{m}$
   B $1.3\,\text{m}$
   C $1.5\,\text{m}$
   D $1.7\,\text{m}$

6   A particle travels at a constant speed around a circle of radius r with centripetal acceleration a. What is the time taken for ten complete rotations?

   A $\dfrac{\pi}{5}\sqrt{\dfrac{a}{r}}$

   B $\dfrac{\pi}{5}\sqrt{\dfrac{r}{a}}$

   C $20\pi\sqrt{\dfrac{a}{r}}$

   D $20\pi\sqrt{\dfrac{r}{a}}$

7   The frequency of a body moving with simple harmonic motion is doubled. If the amplitude remains the same, which one of the following is also doubled?

   A   the time period
   B   the total energy
   C   the maximum velocity
   D   the maximum acceleration

Turn over ▶

8   The time period of a pendulum on Earth is 1.0 s. What would be the period of a pendulum of the same length on a planet with half the density but twice the radius of Earth?

A   0.5 s
B   1.0 s
C   1.4 s
D   2.0 s

9   Which one of the following statements always applies to a damping force acting on a vibrating system?

A   It is in the same direction as the acceleration.
B   It is in the same direction as the displacement.
C   It is in the opposite direction to the velocity.
D   It is proportional to the displacement.

10   Masses of M and $2M$ exert a gravitational force F on each other when the distance between their centres is r. What is the gravitational force between masses of $2M$ and $4M$ when the distance between their centres is $4r$?

A   0.25 F
B   0.50 F
C   0.75 F
D   1.00 F

11   A planet has a radius half the Earth's radius and a mass a quarter of the Earth's mass. What is the approximate gravitational field strength on the surface of the planet?

A $1.6\,\mathrm{N\,kg^{-1}}$
B $5.0\,\mathrm{N\,kg^{-1}}$
C $10\,\mathrm{N\,kg^{-1}}$
D $20\,\mathrm{N\,kg^{-1}}$

12   At the surface of the Earth the gravitational field strength is g, and the gravitational potential is V. The radius of the Earth is R. An object, whose weight on the surface of the Earth is W, is moved to a height $3R$ above the surface. Which line, **A** to **D**, in the table gives the weight of the object and the gravitational potential at this height?

	weight	gravitational potential
A	$\frac{W}{16}$	$\frac{V}{4}$
B	$\frac{W}{4}$	$\frac{V}{3}$
C	$\frac{W}{4}$	$\frac{V}{4}$
D	$\frac{W}{16}$	$\frac{V}{3}$

13   A satellite of mass m travels in a circular orbit of radius r around a planet of mass M. Which one of the following expressions gives the angular speed of the satellite?

     A $\sqrt{GMr}$

     B $\sqrt{Gmr}$

     C $\sqrt{\dfrac{Gm}{r^3}}$

     D $\sqrt{\dfrac{GM}{r^3}}$

14   An electron and a proton are 1.0×10^{-10} m apart. In the absence of any other charges, what is the electric potential energy of the electron?

     A $+2.3 \times 10^{-18}$ J

     B -2.3×10^{-18} J

     C $+2.3 \times 10^{-8}$ J

     D -2.3×10^{-8} J

15

positive ion   uniform electric field 4200 V m^{-1}
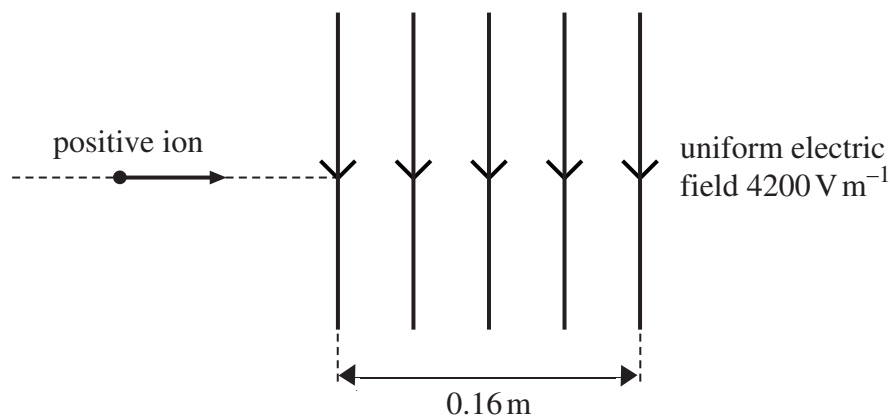
0.16 m

An ion carrying a charge of $+4.8 \times 10^{-19}$ C travels horizontally at a speed of 8.0×10^5 m s^{-1}. It enters a uniform vertical electric field of strength 4200 V m^{-1}, which is directed downwards and acts over a horizontal distance of 0.16m.
Which one of the following statements is **not** correct?

     A   The ion passes through the field in 2.0×10^{-7} s.
     B   The force on the ion acts vertically downwards at all points in the field.
     C   The magnitude of the force exerted on the ion by the field is 1.6×10^{-9} N.
     D   The horizontal component of the velocity of the ion is unaffected by the electric field.

Turn over ▶

16   The electric potential at a distance r from a positive point charge is 45 V. The potential increases to 50 V when the distance from the charge decreases by 1.5 m. What is the value of r?

    A   1.3 m
    B   1.5 m
    C   7.9 m
    D   15 m

17   A 400 µF capacitor is charged so that the voltage across its plates rises at a constant rate from 0 V to 4.0 V in 20 s. What current is being used to charge the capacitor?

    A   5 µA
    B   20 µA
    C   40 µA
    D   80 µA

18   A capacitor of capacitance C stores an amount of energy E when the pd across it is V. Which line, **A** to **D**, in the table gives the correct stored energy and pd when the charge is increased by 50%?

	energy	pd
A	1.5 E	1.5 V
B	1.5 E	2.25 V
C	2.25 E	1.5 V
D	2.25 E	2.25 V

19   A capacitor of capacitance C discharges through a resistor of resistance R. Which one of the following statements is **not** true?

    A   The time constant will decrease if C is increased.
    B   The time constant will increase if R is increased.
    C   After charging to the same voltage, the initial discharge current will increase if R is decreased.
    D   After charging to the same voltage, the initial discharge current will be unaffected if C is increased.

20   The graph shows how the charge on a capacitor varies with time as it is discharged through a resistor.
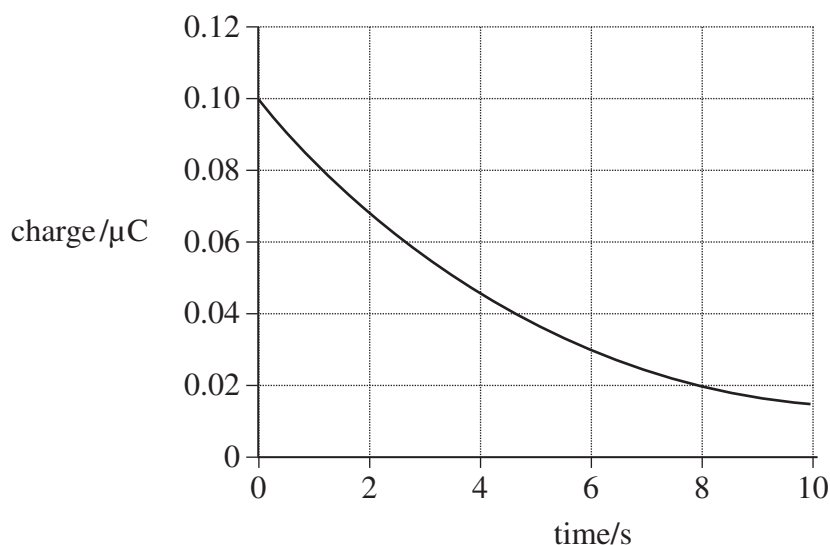
What is the time constant for the circuit?

A   3.0 s
B   4.0 s
C   5.0 s
D   8.0 s

21   Two charged particles, P and Q, move in circular orbits in a magnetic field of uniform flux density. The particles have the same charge but the mass of P is less than the mass of Q. T_P is the time taken for particle P to complete one orbit and T_Q the time for particle Q to complete one orbit. Which one of the following is correct?

A $T_P = T_Q$

B $T_P > T_Q$

C $T_P < T_Q$

D $T_P - T_Q = 1$

Turn over ▶

22   The graph shows how the flux linkage, $N\Phi$, through a coil changes when the coil is moved into a magnetic field.
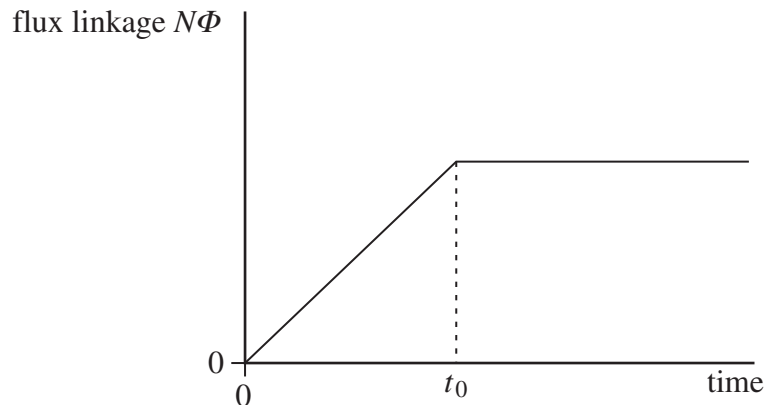
The emf induced in the coil

A   increases then becomes constant after time t_0.
B   is constant then becomes zero after time t_0.
C   is zero then increases after time t_0.
D   decreases then becomes zero after time t_0.

23   A bar magnet is pushed into a coil connected to a sensitive ammeter, as shown in the diagram, until it comes to rest inside the coil.
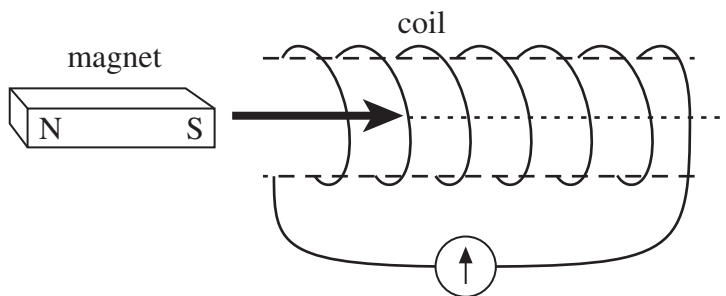
Why does the ammeter briefly show a non-zero reading?

A   The magnetic flux linkage in the coil increases then decreases.
B   The magnetic flux linkage in the coil increases then becomes constant.
C   The magnetic flux linkage in the coil decreases then increases.
D   The magnetic flux linkage in the coil decreases then becomes constant.

24
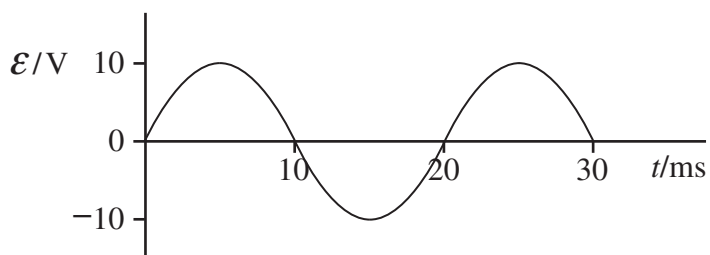
The above graph shows how the output emf, $\mathcal{E}$, varies with time, t, for a coil rotating at angular speed ω in a uniform magnetic field of flux density B. Which one of the following graphs shows how $\mathcal{E}$ varies with t when the same coil is rotated at angular speed 2ω in a uniform magnetic field of flux density $0.5\ B$?

A

B

C

D
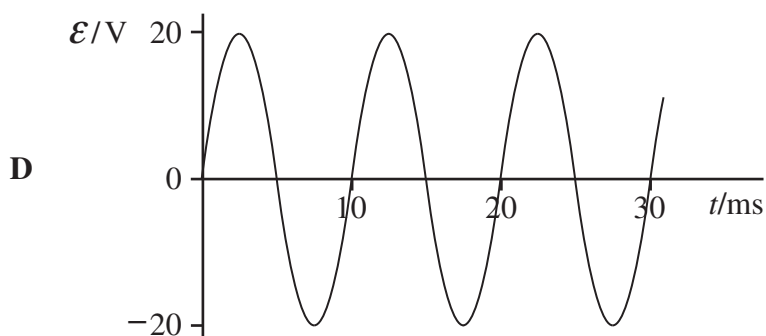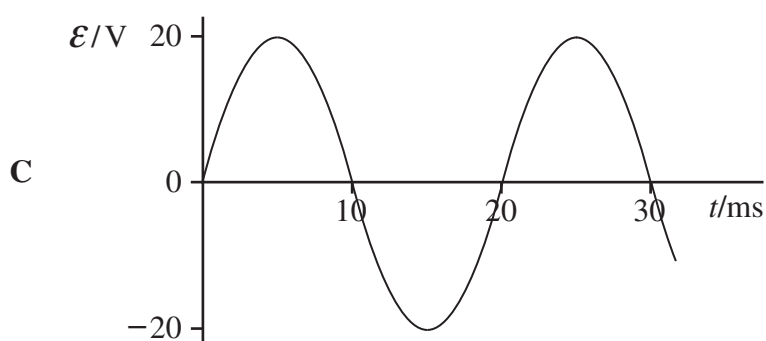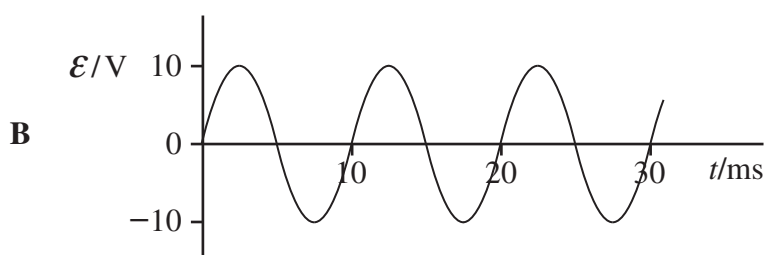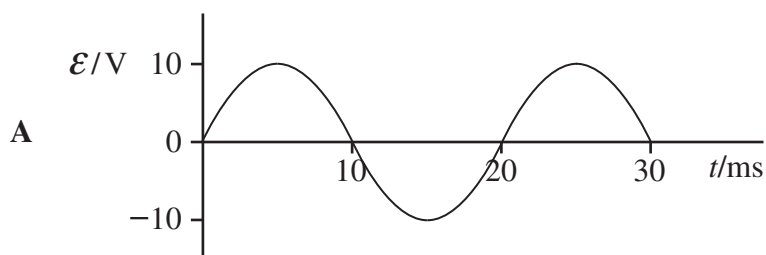
Turn over ▶

25   Which one of the following is **not** a cause of energy loss in a transformer?

    A   good insulation between the primary and secondary coil
    B   induced currents in the soft iron core
    C   reversal of magnetism in the soft iron core
    D   resistances in the primary and secondary coil

END OF QUESTIONS

Surname

Other Names

Candidate Signature

AQA

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Physics A   PHYA4/2

Unit 4   Fields and Further Mechanics
Section B

Tuesday 21 June 2011 9.00 am to 10.45 am

For this paper you must have:
- a calculator
- a ruler
- 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 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 space 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

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper 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
You are advised to spend approximately **one hour** on this section

1   **Figure 1** shows a parcel on the floor of a delivery van that is passing over a
hump-backed bridge on a straight section of road. The radius of curvature of the
path of the parcel is *r* and the van is travelling at a constant speed *v*. The mass
of the parcel is *m*.
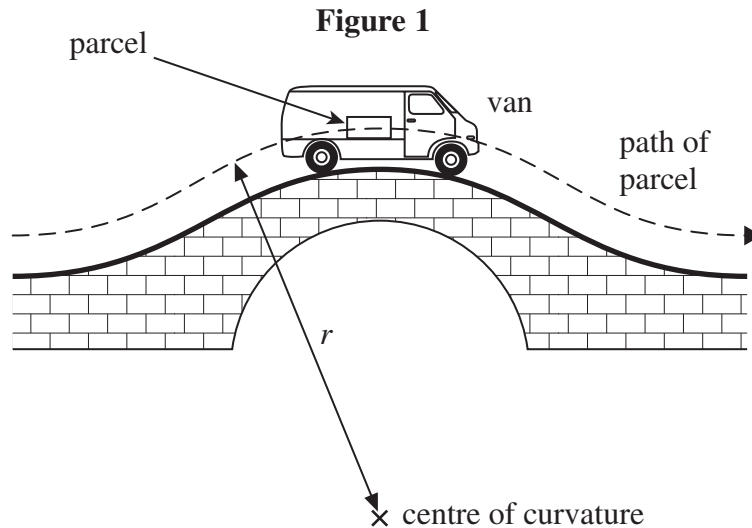
Figure 1

1 (a) (i)   Draw arrows on **Figure 2** below to show the forces that act on the parcel as it passes
over the highest point of the bridge. Label these forces.

(1 mark)

Figure 2
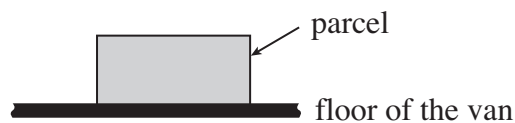
1 (a) (ii)   Write down an equation that relates the contact force, *R*, between the parcel and the
floor of the van to *m*, *v*, *r* and the gravitational field strength, *g*.

....

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(1 mark)

1 (a) (iii) Calculate R if $m = 12\,\text{kg}$, $r = 23\,\text{m}$, and $v = 11\,\text{m\,s}^{-1}$.

answer = ...N

(2 marks)

1 (b) Explain what would happen to the magnitude of R if the van passed over the bridge at a higher speed. What would be the significance of any van speed greater than $15\,\text{m\,s}^{-1}$? Support your answer with a calculation.

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(3 marks)

7

Turn over ▶

2   A trolley of mass 0.80 kg rests on a horizontal surface attached to two identical stretched springs, as shown in **Figure 3**. Each spring has a spring constant of $30\,N\,m^{-1}$, can be assumed to obey Hooke's law, and to remain in tension as the trolley moves.

Figure 3
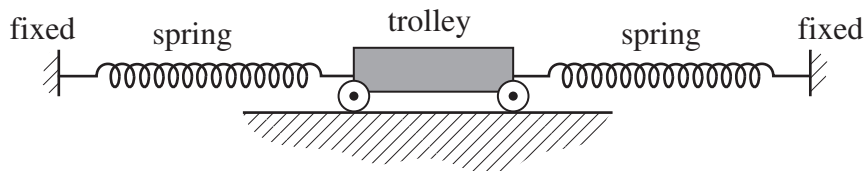
2 (a) (i)   The trolley is displaced to the left by 60 mm and then released. Show that the magnitude of the resultant force on it at the moment of release is 3.6 N.

(2 marks)

2 (a) (ii)   Calculate the acceleration of the trolley at the moment of release and state its direction.

answer = ...$m\,s^{-2}$

direction ....

(2 marks)

2 (b) (i) The oscillating trolley performs simple harmonic motion. State the **two** conditions which have to be satisfied to show that a body performs simple harmonic motion.

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(2 marks)

2 (b) (ii) The frequency *f* of oscillation of the trolley is given by

$$f = \frac{1}{2\pi}\sqrt{\frac{2k}{m}}$$

where *m* = mass of the trolley
        k = spring constant of one spring.

Calculate the period of oscillation of the trolley, stating an appropriate unit.

answer = ...

(3 marks)

Turn over ▶

2 (c)   Copper ions in a crystal lattice vibrate in a similar way to the trolley, because the inter-atomic forces act in a similar way to the forces exerted by the springs. **Figure 4** shows how this model of a vibrating ion can be represented.

Figure 4
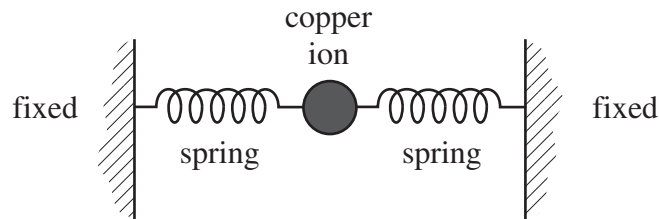
2 (c) (i)   The spring constant of each inter-atomic 'spring' is about $200\,\mathrm{N\,m^{-1}}$. The mass of the copper ion is $1.0 \times 10^{-25}\,\mathrm{kg}$. Show that the frequency of vibration of the copper ion is about $10^{13}\,\mathrm{Hz}$.

(1 mark)

2 (c) (ii)   If the amplitude of vibration of the copper ion is 10^{-11}m, estimate its maximum speed.

answer = ...$\mathrm{m\,s^{-1}}$

(1 mark)

2 (c) (iii) Estimate the maximum kinetic energy of the copper ion.

answer = ...J

(1 mark)

3   Capacitors and rechargeable batteries are examples of electrical devices that can be used repeatedly to store energy.

3 (a) (i)   A capacitor of capacitance 70 F is used to provide the emergency back-up in a low voltage power supply.
Calculate the energy stored by this capacitor when fully charged to its maximum operating voltage of 1.2 V. Express your answer to an appropriate number of significant figures.

answer = ...J
(3 marks)

3 (a) (ii)   A rechargeable 1.2 V cell used in a cordless telephone can supply a steady current of 55 mA for 10 hours. Show that this cell, when fully charged, stores almost 50 times more energy than the capacitor in part (a)(i).

(2 marks)

3 (b)   Give **two** reasons why a capacitor is **not** a suitable source for powering a cordless telephone.

Reason 1..

....

Reason 2..

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(2 marks)

7

Turn over ▶

4 (a)   The equation $F = B Q v$ may be used to calculate magnetic forces.

4 (a) (i)   State the condition under which this equation applies.

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(1 mark)

4 (a) (ii)   Identify the physical quantities that are represented by the four symbols in the equation.

F ....

B ....

Q...

v...

(1 mark)

4 (b)   **Figure 5** shows the path followed by a stream of identical positively-charged ions, of the same kinetic energy, as they pass through the region between two charged plates. Initially the ions are travelling horizontally and they are then deflected downwards by the electric field between the plates.

Figure 5
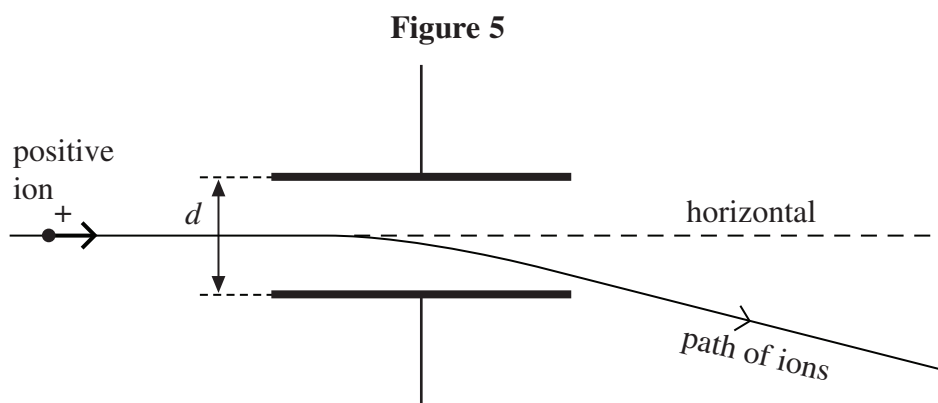
Whilst the electric field is still applied, the path of the ions may be restored to the horizontal, so that they have no overall deflection, by applying a magnetic field over the same region as the electric field. The magnetic field must be of suitable strength and has to be applied in a particular direction.

4 (b) (i)   State the direction in which the magnetic field should be applied.

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(1 mark)

4 (b) (ii) Explain why the ions have no overall deflection when a magnetic field of the required strength has been applied.

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(2 marks)

4 (b) (iii) A stream of ions passes between the plates at a velocity of $1.7 \times 10^5 \, \text{m s}^{-1}$. The separation d of the plates is 65 mm and the pd across them is 48 V. Calculate the value of B required so that there is no overall deflection of the ions, stating an appropriate unit.

answer = ...

(4 marks)

4 (c) Explain what would happen to ions with a velocity higher than $1.7 \times 10^5 \, \text{m s}^{-1}$ when they pass between the plates at a time when the conditions in part (b)(iii) have been established.

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(2 marks)

11

Turn over ▶

5 (a) Long cables are used to send electrical power from a supply point to a factory some distance away, as shown in **Figure 6**. An input power of 500 kW at 25 kV is supplied to the cables.

Figure 6
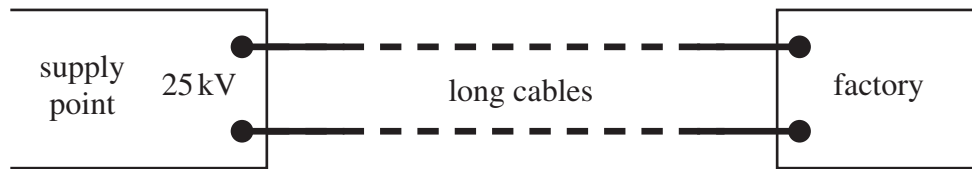
5 (a) (i) Calculate the current in the cables.

answer = ...A
(1 mark)

5 (a) (ii) The total resistance of the cables is 30 Ω. Calculate the power supplied to the factory by the cables.

answer = ...kW
(2 marks)

5 (a) (iii) Calculate the efficiency with which power is transmitted by the cables from the input at the supply point to the factory.

answer = ...%
(1 mark)

5 (b) In Great Britain, the electrical generators at power stations provide an output at 25 kV. Most homes, offices and shops are supplied with electricity at 230 V. Power is transmitted from the power stations to the consumers by the grid system, the main principles of which are shown in **Figure 7**. In this network, T_1, T_2, T_3, etc, are transformers.

Figure 7
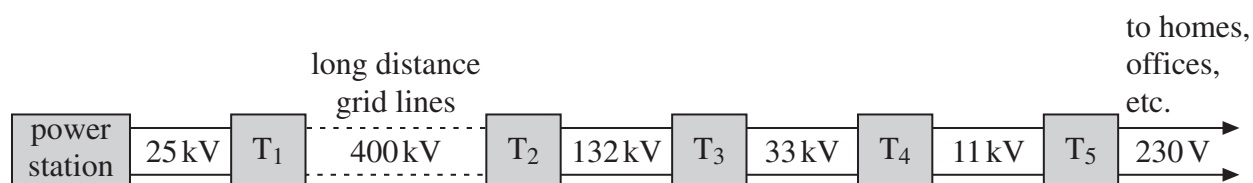
5 (b) (i) Explain how a step-down transformer differs in construction from a step-up transformer.

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(1 mark)

5 (b) (ii) Explain why the secondary windings of a step-down transformer should be made from thicker copper wire than the primary windings.

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(2 marks)

Question 5 continues on the next page

Turn over ▶

5 (c) Discuss the principles involved in high voltage transmission systems, explaining why a.c. is used in preference to d.c. and how the energy losses are minimised.

The quality of your written communication will be assessed in this question.

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(6 marks)

13

END OF QUESTIONS