Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

General Certificate of Education
Advanced Level Examination
January 2011

Physics A PHYA4/1

Unit 4 Fields and Further Mechanics
Section A

Thursday 27 January 2011 1.30pm 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.

ERRATUM NOTICE

General Certificate of Education
January 2011

PHYSICS A PHYA4/1

Unit 4 Fields and Further Mechanics
Section A

Thursday 27 January 2011 1.30 pm to 3.15 pm

Instructions to Invigilators

Before the start of the examination please ask candidates to amend their question papers as follows. (Please read out this message twice to ensure understanding.)

In PHYA4/1 (Section A), Turn to page 7, Question 15

Cross through the question and do not attempt to complete it.

On the OTQ answer sheet

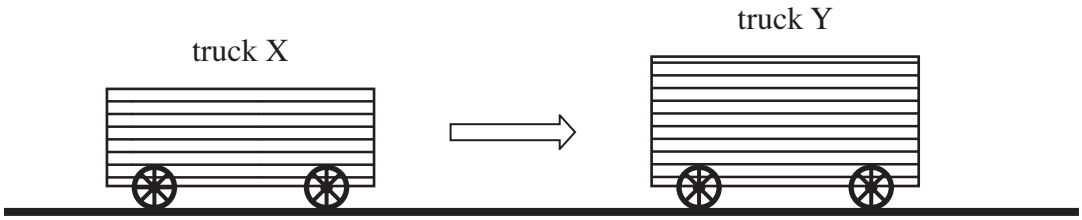
Please make sure you leave the answer space for question 15 blank.

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.

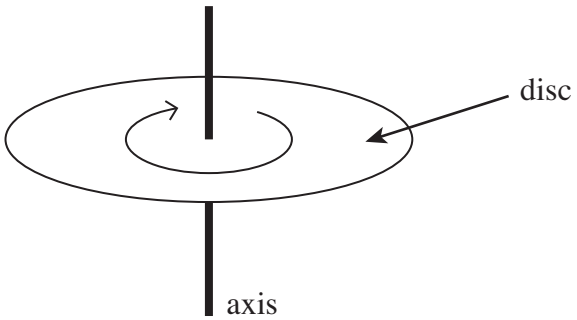
1 A rail truck X travels along a level track and collides with a stationary truck Y. The two trucks move together at the same velocity after the collision.



Which line, **A** to **D**, in the table states how the total momentum and the total kinetic energy of the trucks change as a result of the impact.

	total momentum	**total kinetic energy**
A	unchanged	unchanged
B	unchanged	decreases
C	decreases	decreases
D	decreases	unchanged

2 The diagram shows a disc of diameter 120mm that can turn about an axis through its centre.



The disc is turned through an angle of 30° in 20 ms. What is the average speed of a point on the edge of the disc during this time?

A $0.5\pi\,\text{m s}^{-1}$

B $\pi\,\text{m s}^{-1}$

C $1.5\pi\,\text{m s}^{-1}$

D $2\pi\,\text{m s}^{-1}$

3 A particle of mass m moves in a circle of radius r at a uniform speed with frequency f. What is the kinetic energy of the particle?

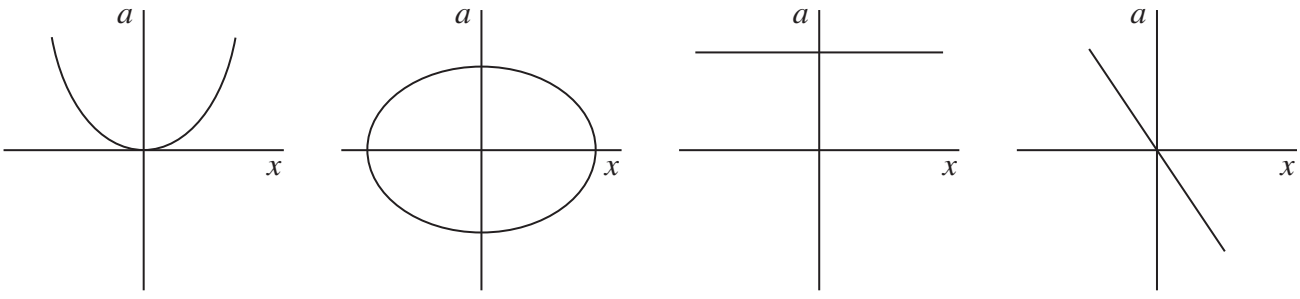
A $\dfrac{mf^2r^2}{4\pi^2}$

B $\dfrac{mf^2r}{2}$

C $2\pi^2 mf^2r^2$

D $4\pi^2 mf^2r^2$

4 Which one of the following graphs shows how the acceleration, a, of a body moving with simple harmonic motion varies with its displacement, x?



Turn over ▶

5 A body moves with simple harmonic motion of amplitude A and frequency $\frac{b}{2\pi}$.

What is the magnitude of the acceleration when the body is at maximum displacement?

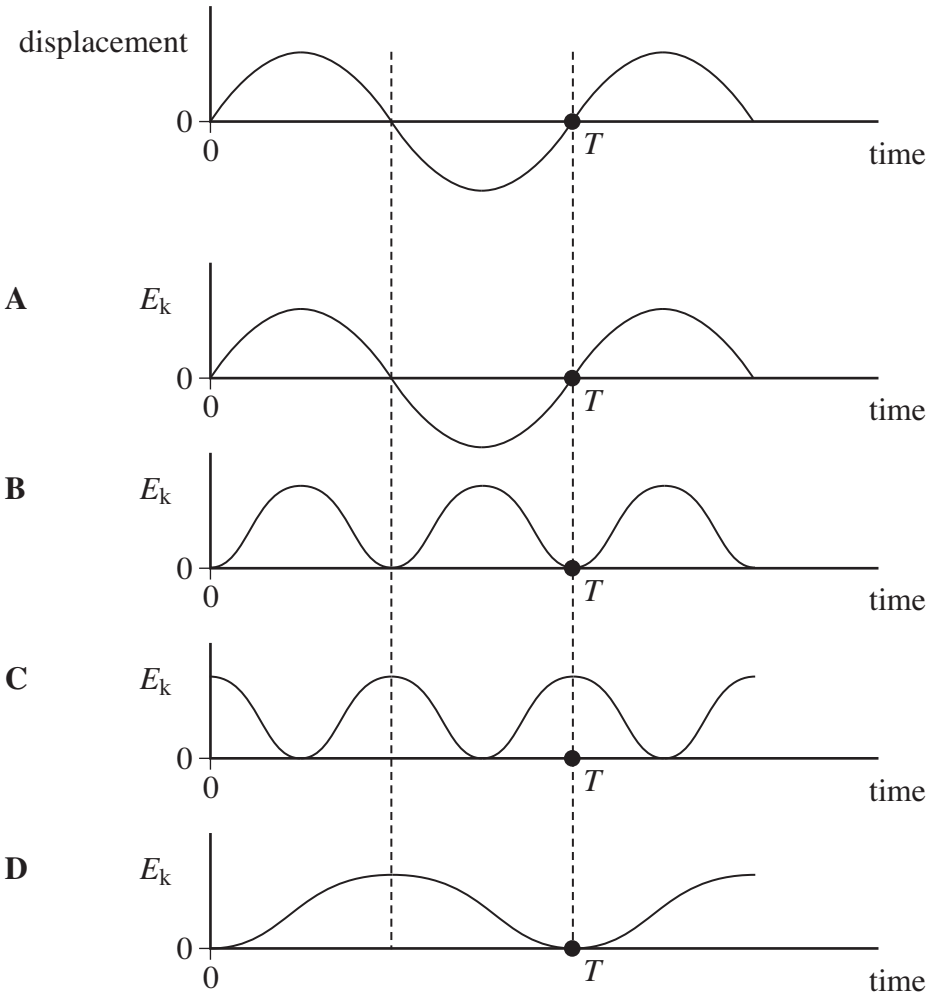
A zero

B $4\pi^2 Ab^2$

C Ab^2

D $\frac{4\pi^2 A}{b^2}$

6 An object oscillating in simple harmonic motion has a time period T. The first graph shows how its displacement varies with time. Which of the subsequent graphs, **A** to **D**, show how the kinetic energy, E_k, of the object varies with time?



7 The period of vertical oscillation of a mass-spring system is T when the spring carries a mass of 1.00 kg. What mass should be added to the 1.00 kg if the period is to be increased to 1.50 T?

A 0.25 kg

B 1.00 kg

C 1.25 kg

D 2.00 kg

8 The gravitational force between two uniform spheres is 3.1×10^{-9} N when the distance between their centres is 150 mm. If the mass of one sphere is 2.5 kg, what is the mass of the other?

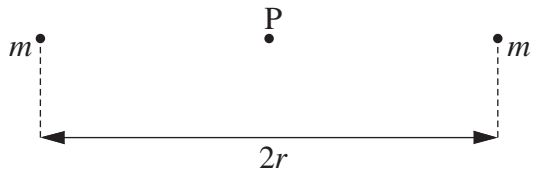
A 0.043 kg

B 0.42 kg

C 2.8 kg

D 4.1 kg

9 The diagram shows two point masses each of mass m separated by a distance $2r$.



What is the value of the gravitational field strength at the mid-point, P, between the two masses?

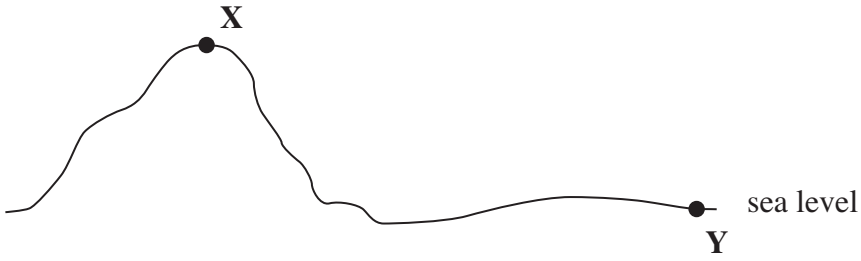
A $\frac{4Gm}{r^2}$

B $\frac{2Gm}{r^2}$

C $\frac{Gm}{2r^2}$

D zero

10 The diagram shows two positions, **X** and **Y**, on the Earth's surface.



Which line, **A** to **D**, in the table gives correct comparisons at **X** and **Y** for gravitational potential and angular velocity?

	gravitational potential at X compared with Y	**angular velocity at X compared with Y**
A	greater	greater
B	greater	same
C	greater	smaller
D	same	same

11 What would the period of rotation of the Earth need to be if objects at the equator were to appear weightless?

radius of Earth = 6.4×10^6 m

A 4.5×10^{-2} hours

B 1.4 hours

C 24 hours

D 160 hours

12 As a comet orbits the Sun the distance between the comet and the Sun continually changes. As the comet moves towards the Sun this distance reaches a minimum value. Which one of the following statements is **incorrect** as the comet approaches this minimum distance?

A The potential energy of the comet increases.

B The gravitational force acting on the comet increases.

C The direction of the gravitational force acting on the comet changes.

D The kinetic energy of the comet increases.

13 The repulsive force between two small negative charges separated by a distance r is F.

What is the force between the charges when the separation is reduced to $\frac{r}{3}$?

A $\frac{F}{9}$

B $\frac{F}{3}$

C $3F$

D $9F$

14 What is the acceleration of an electron at a point in an electric field where the field strength is 1.5×10^5 Vm^{-1}?

A 1.2×10^6 m s^{-2}

B 1.4×10^{13} m s^{-2}

C 2.7×10^{15} m s^{-2}

D 2.6×10^{16} m s^{-2}

15 At a distance R from a fixed charge, the electric field strength is E and the electric potential is V. Which line, **A** to **D**, in the table gives the electric field strength and electric potential at a distance $2R$ from the charge?

	electric field strength	**electric potential**
A	$\frac{E}{2}$	$\frac{V}{4}$
B	$\frac{E}{2}$	$\frac{V}{2}$
C	$\frac{E}{4}$	$\frac{V}{2}$
D	$\frac{E}{4}$	$\frac{V}{4}$

16 Two protons are 1.0×10^{-14}m apart. Approximately how many times is the electrostatic force between them greater than the gravitational force between them?
(Use the Data and Formulae booklet)

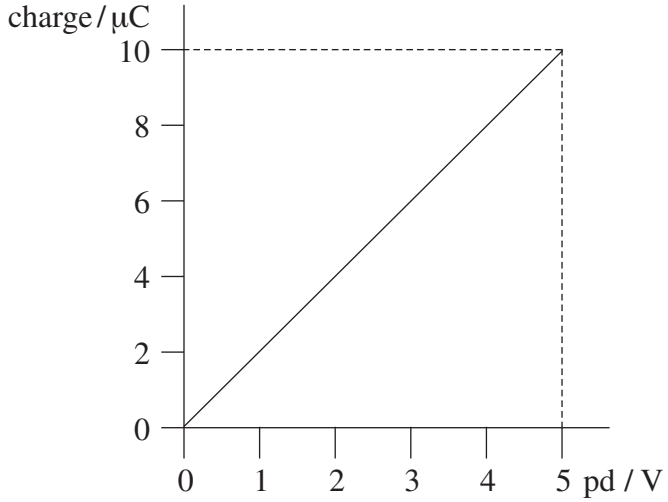
A 10^{23}

B 10^{30}

C 10^{36}

D 10^{42}

17 The graph shows how the charge stored by a capacitor varies with the pd applied across it.



Which line, **A** to **D**, in the table gives the capacitance and the energy stored when the potential difference is 5.0 V?

	capacitance/μF	**energy stored/μJ**
A	2.0	25
B	2.0	50
C	10.0	25
D	10.0	50

18 A 10 mF capacitor is charged to 10 V and then discharged completely through a small motor. During the process, the motor lifts a weight of mass 0.10 kg. If 10% of the energy stored in the capacitor is used to lift the weight, through what approximate height will the weight be lifted?

A 0.05 m

B 0.10 m

C 0.50 m

D 1.00 m

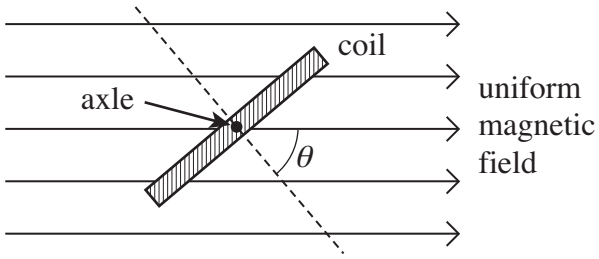
19 A negatively charged particle moves at right angles to a uniform magnetic field. The magnetic force on the particle acts

A in the direction of the field.
B in the opposite direction to that of the field.
C at an angle between 0^o and 90^o to the field.
D at right angles to the field.

20 An electron moving with a constant speed enters a uniform magnetic field in a direction perpendicular to the magnetic field. What is the shape of the path that the electron would follow?

A parabolic
B circular
C elliptical
D a line parallel to the magnetic field

21



A coil of 50 turns has a cross-sectional area of $4.2 \times 10^{-3}\,m^2$. It is placed at an angle to a uniform magnetic field of flux density $2.8 \times 10^{-2}\,T$, as shown in the diagram, so that angle $\theta = 50^o$.

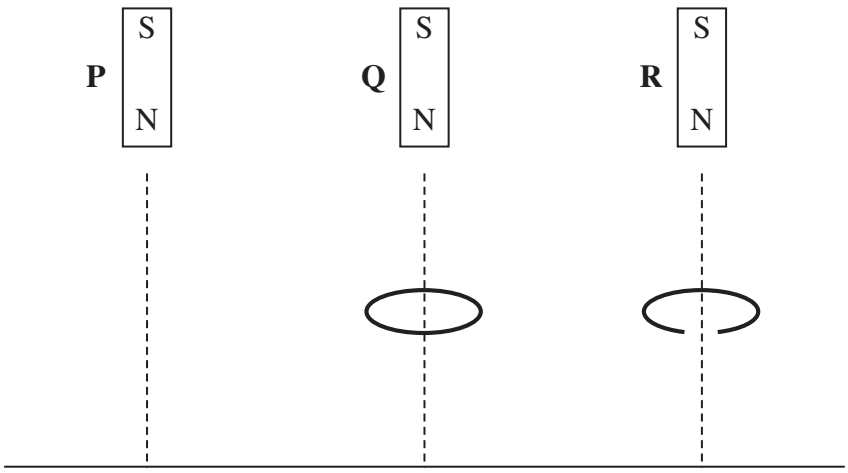
What is the change in flux linkage when the coil is rotated anticlockwise until $\theta = 0^o$?

A The flux linkage decreases by 2.1×10^{-3} Wb turns.
B The flux linkage increases by 2.1×10^{-3} Wb turns.
C The flux linkage decreases by 3.8×10^{-3} Wb turns.
D The flux linkage increases by 3.8×10^{-3} Wb turns.

22 An aircraft, of wing span 60 m, flies horizontally at a speed of $150\,m\,s^{-1}$. If the vertical component of the Earth's magnetic field in the region of the plane is 1.0×10^{-5}T, what is the magnitude of the magnetic flux cut by the wings in 10 s?

A 1.0×10^{-5} Wb
B 1.0×10^{-4} Wb
C 9.0×10^{-2} Wb
D 9.0×10^{-1} Wb

23



Three identical magnets **P**, **Q** and **R** are released simultaneously from rest and fall to the ground from the same height. **P** falls directly to the ground, **Q** falls through the centre of a thick conducting ring and **R** falls through a ring which is identical except for a gap cut into it. Which one of the statements below correctly describe the sequence in which the magnets reach the ground?

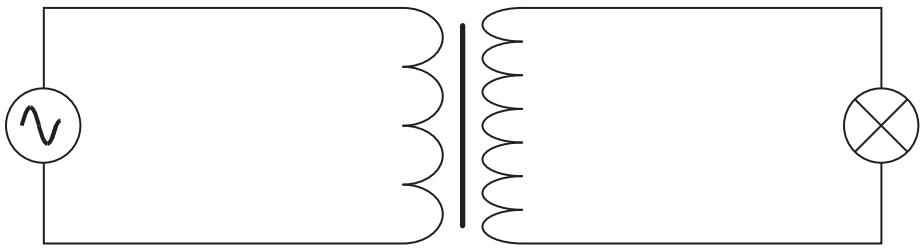
A **P** and **R** arrive together followed by **Q**.

B **P** and **Q** arrive together followed by **R**.

C **P** arrives first, follow by **Q** which is followed by **R**.

D All three magnets arrive simultaneously.

24 The primary coil of a step-up transformer is connected to a source of alternating pd. The secondary coil is connected to a lamp.



Which line, **A** to **D**, in the table correctly describes the flux linkage and current through the secondary coil in relation to the primary coil?

	$\frac{\text{secondary magnetic flux linkage}}{\text{primary magnetic flux linkage}}$	$\frac{\text{secondary current}}{\text{primary current}}$
A	>1	<1
B	<1	<1
C	>1	>1
D	<1	>1

25 A transformer has 1200 turns on the primary coil and 500 turns on the secondary coil. The primary coil draws a current of 0.25 A from a 240 V ac supply. If the efficiency of the transformer is 83%, what is the current in the secondary coil?

A 0.10 A

B 0.21 A

C 0.50 A

D 0.60 A

END OF QUESTIONS

Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
TOTAL	

General Certificate of Education
Advanced Level Examination
January 2011

Physics A PHYA4/2

Unit 4 Fields and Further Mechanics
Section B

Thursday 27 January 2011 1.30 pm to 3.15 pm

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 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.

There are no questions printed on this page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

Answer **all** questions
You are advised to spend approximately **one hour** on this section

1 The Hubble space telescope was launched in 1990 into a circular orbit near to the Earth. It travels around the Earth once every 97 minutes.

1 (a) Calculate the angular speed of the Hubble telescope, stating an appropriate unit.

answer = ...
(3 marks)

1 (b) (i) Calculate the radius of the orbit of the Hubble telescope.

answer = ... m
(3 marks)

1 (b) (ii) The mass of the Hubble telescope is 1.1×10^4 kg. Calculate the magnitude of the centripetal force that acts on it.

answer = ... N
(2 marks)

8

2 (a) State, in words, how the force acting on a body is related to the change in momentum of the body.

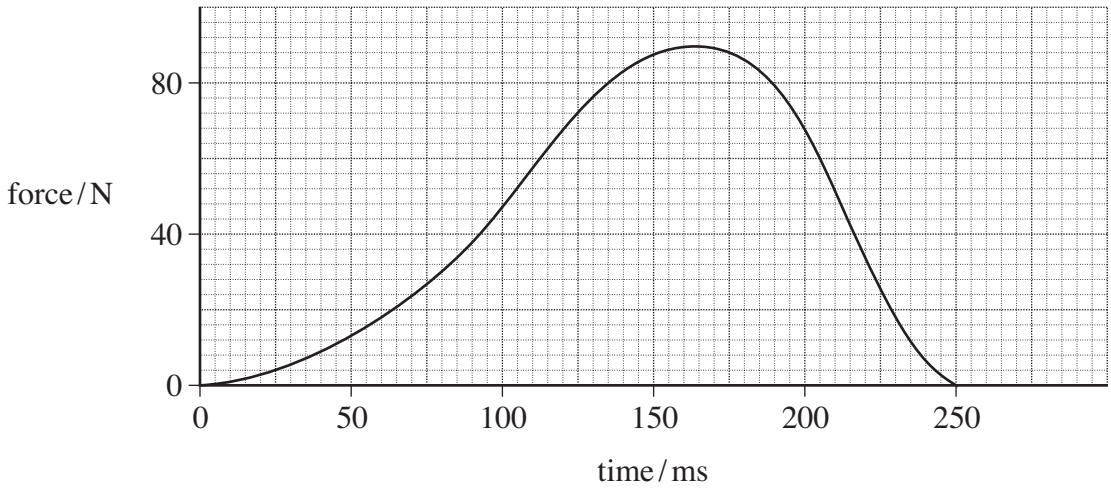
.....

.....

(1 mark)

2 (b) A football of mass 0.42 kg is moving horizontally at 10 m s^{-1} towards a footballer's boot, which then kicks it. **Figure 1** shows how the force between the boot and the ball varies with time while they are in contact.

Figure 1



2 (b) (i) What is the significance of the area enclosed by the line on a force–time graph and the time axis when a force acts on a body for a short time?

.....

(1 mark)

2 (b) (ii) Estimate the impulse that acts on the ball, stating an appropriate unit.

answer = ...

(4 marks)

2 (b) (iii) Calculate the speed of the ball after it has been kicked, assuming that it returns along the same horizontal line it followed when approaching the boot. Express your answer to an appropriate number of significant figures.

answer = ...m s^{-1}

(4 marks)

2 (c) Discuss the consequences if the ball had approached the boot at a higher speed but still received the same impulse.

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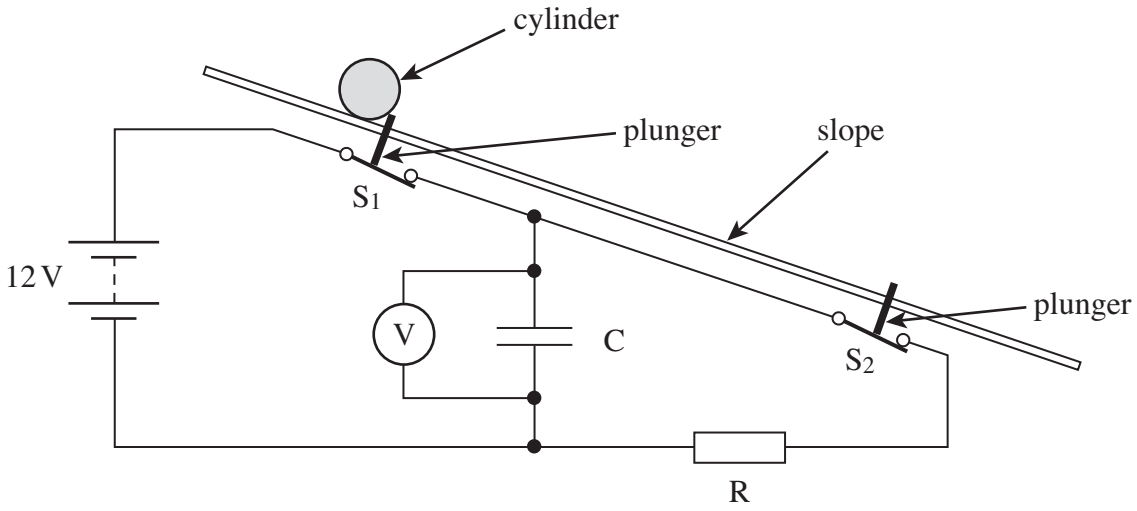
(3 marks)

13

3 A student was required to design an experiment to measure the acceleration of a heavy cylinder as it rolled down an inclined slope of constant gradient. He suggested an arrangement that would make use of a capacitor-resistor discharge circuit to measure the time taken for the cylinder to travel between two points on the slope. The principle of this arrangement is shown in **Figure 2**.

Figure 2



S_1 and S_2 are two switches that would be opened in turn by plungers as the cylinder passed over them. Once opened, the switches would remain open. The cylinder would be released from rest as it opened S_1. The pd across the capacitator would be measured by the voltmeter.

3 (a) Describe the procedure the student should follow, including the measurements he should make, when using this arrangement. Explain how he should use the measurements taken to calculate the acceleration of the cylinder down the slope.

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

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(6 marks)

3 (b) When the student set up his experiment using the arrangement shown in **Figure 2**, he used a 22 μF capacitor, C, and a 200 kΩ resistor, R. In one of his results, the initial pd was 12.0 V and the final pd was 5.8 V. The distance between the plungers was 2.5 m.

3 (b) (i) From the student's result, calculate the time taken for the cylinder to reach the second plunger.

answer = ...s

(3 marks)

3 (b) (ii) What value does this result give for the acceleration of the cylinder down the slope, assuming the acceleration is constant?

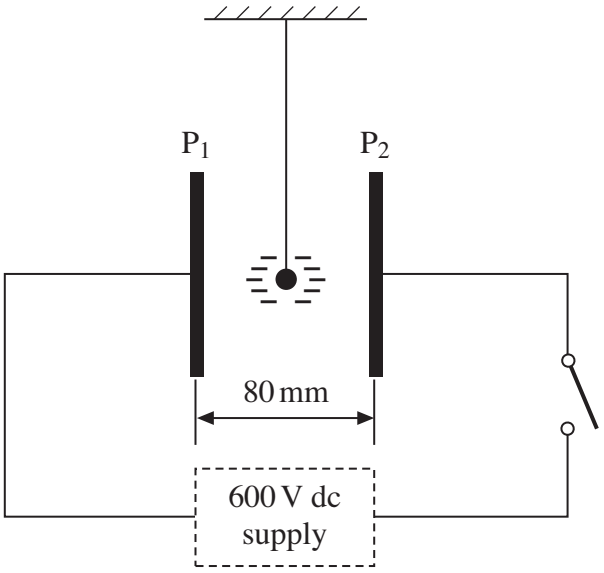
answer = ...m s^{-2}

(2 marks)

11

4 **Figure 3** shows a small polystyrene ball which is suspended between two vertical metal plates, $\mathbf{P_1}$ and $\mathbf{P_2}$, 80 mm apart, that are initially uncharged. The ball carries a charge of –0.17 μC.

Figure 3



4 (a) (i) A pd of 600 V is applied between $\mathbf{P_1}$ and $\mathbf{P_2}$ when the switch is closed. Calculate the magnitude of the electric field strength between the plates, assuming it is uniform.

answer = ...V m^{-1}

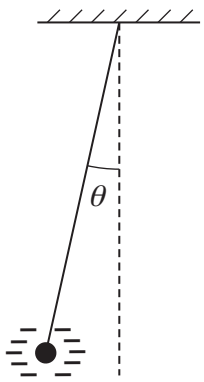
(2 marks)

4 (a) (ii) Show that the magnitude of the electrostatic force that acts on the ball under these conditions is 1.3 mN.

(1 mark)

4 (b) Because of the electrostatic force acting on it, the ball is displaced from its original position. It comes to rest when the suspended thread makes an angle θ with the vertical, as shown in **Figure 4**.

Figure 4



4 (b) (i) On **Figure 4**, mark and label the forces that act on the ball when in this position.

(2 marks)

4 (b) (ii) The mass of the ball is 4.8×10^{-4} kg. By considering the equilibrium of the ball, determine the value of θ.

answer = ...degrees

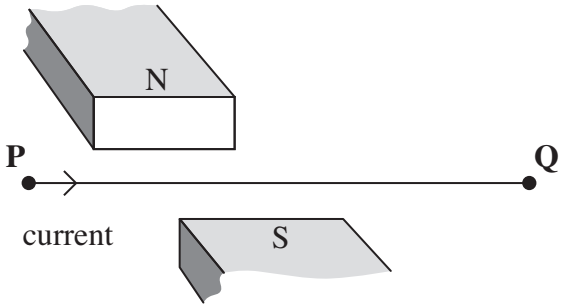
(3 marks)

8

Turn over ▶

5 **Figure 5** shows a horizontal wire, held in tension between fixed points at **P** and **Q**. A short section of the wire is positioned between the pole pieces of a permanent magnet, which applies a uniform horizontal magnetic field at right angles to the wire. Wires connected to a circuit at **P** and **Q** allow an electric current to be passed through the wire.

Figure 5



5 (a) (i) State the direction of the force on the wire when there is a direct current from **P** to **Q**, as shown in **Figure 5**.

.....

(1 mark)

5 (a) (ii) In a second experiment, an alternating current is passed through the wire. Explain why the wire will vibrate vertically.

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(3 marks)

5 (b) The permanent magnet produces a uniform magnetic field of flux density 220 mT over a 55 mm length of the wire. Show that the maximum force on the wire is about 40 mN when there is an alternating current of rms value 2.4 A in it.

(3 marks)

5 (c) The length of **PQ** is 0.40 m. When the wire is vibrating, transverse waves are propagated along the wire at a speed of 64 m s^{-1}. Explain why the wire is set into large amplitude vibration when the frequency of the a.c. supply is 80 Hz.

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(3 marks)

10

END OF QUESTIONS