Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

General Certificate of Education
Advanced Level Examination
January 2012

Physics A PHYA4/1

Unit 4 Fields and Further Mechanics
Section A

Tuesday 24 January 2012 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.

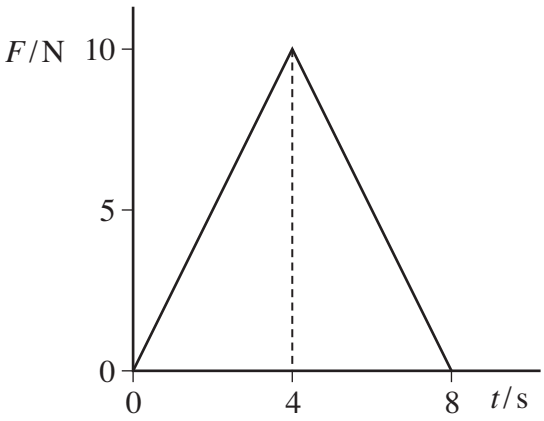
Information
- The maximum mark for this section is 25.
- All questions in Section A carry equal marks. No deductions will be made for incorrect answers.
- A *Data and Formulae Booklet* is provided as a loose insert.
- The question paper/answer book for Section B is enclosed within this question paper.

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 2.0 kg, initially at rest, is acted on by a force F which varies with time t as shown by the graph.



What is the velocity of the ball after 8.0 s?

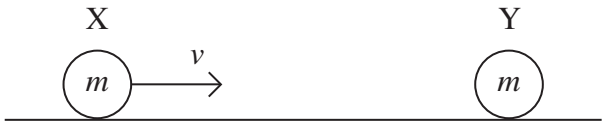
A $20\,\text{m s}^{-1}$

B $40\,\text{m s}^{-1}$

C $80\,\text{m s}^{-1}$

D $160\,\text{m s}^{-1}$

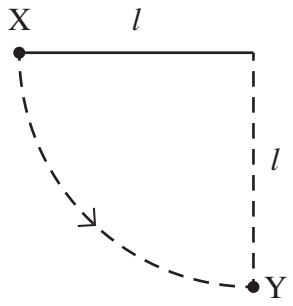
2 A body X moving with a velocity v makes an elastic collision with a stationary body Y of equal mass on a smooth horizontal surface.



Which line, **A** to **D**, in the table gives the velocities of the two bodies after the collision?

	velocity of X	**velocity of Y**
A	$\frac{v}{2}$	$-\frac{v}{2}$
B	$-\frac{v}{2}$	$\frac{v}{2}$
C	v	0
D	0	v

3 A ball of mass m, which is fixed to the end of a light string of length l, is released from rest at X.
It swings in a circular path, passing through the lowest point Y at speed v.



If the tension in the string at Y is T, which one of the following equations represents a correct application of Newton's laws of motion to the ball at Y?

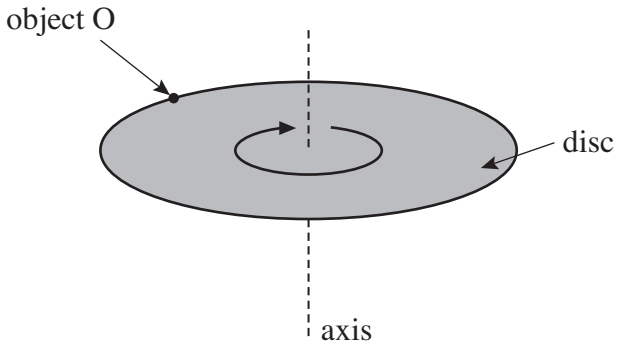
A $T = \frac{mv^2}{l} - mg$

B $mg - T = \frac{mv^2}{l}$

C $T - mg = \frac{mv^2}{l}$

D $T + \frac{mv^2}{l} = mg$

4 A disc of diameter D is turning at a steady angular speed at frequency f about an axis through its centre.



What is the centripetal force on a small object O of mass m on the perimeter of the disc?

A $2\pi mfD$

B $2\pi mf^2D$

C $2\pi^2mf^2D$

D $2\pi mf^2D^2$

5 What is the angular speed of a car wheel of diameter 0.400 m when the speed of the car is 108 km h^{-1}?

A 75 rad s^{-1}

B 150 rad s^{-1}

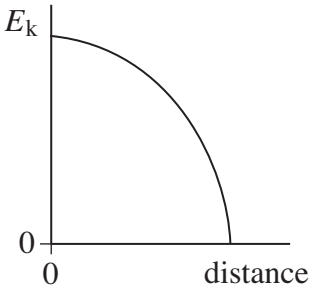
C 270 rad s^{-1}

D 540 rad s^{-1}

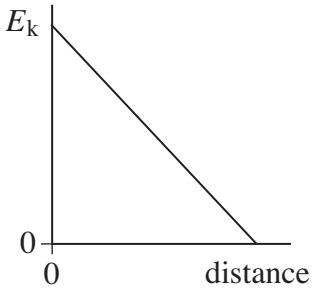
6 Which one of the following statements is true when an object performs simple harmonic motion about a central point O?

A The acceleration is always directed away from O.
B The acceleration and velocity are always in opposite directions.
C The acceleration and the displacement from O are always in the same direction.
D The graph of acceleration against displacement is a straight line.

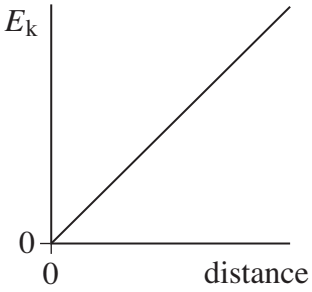
7 A body executes simple harmonic motion. Which one of the graphs, **A** to **D**, best shows the relationship between the kinetic energy, E_k, of the body and its distance from the centre of oscillation?



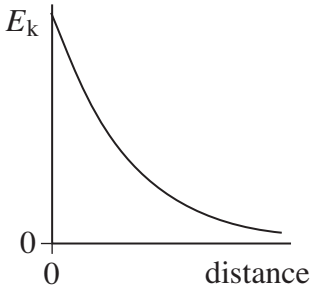
A



B



C



D

8 A mechanical system is oscillating at resonance with a constant amplitude. Which one of the following statements is **not** correct?

A The applied force prevents the amplitude from becoming too large.
B The frequency of the applied force is the same as the natural frequency of oscillation of the system.
C The total energy of the system is constant.
D The amplitude of oscillations depends on the amount of damping.

9 Which one of the following statements about Newton's law of gravitation is correct?

Newton's law of gravitation explains

A the origin of gravitational forces.
B why a falling satellite burns up when it enters the Earth's atmosphere.
C why projectiles maintain a uniform horizontal speed.
D how various factors affect the gravitational force between two particles.

10 If an electron and proton are separated by a distance of 5×10^{-11}m, what is the approximate gravitational force of attraction between them?

A 2×10^{-57}N

B 3×10^{-47}N

C 4×10^{-47}N

D 5×10^{-37}N

11 A spherical planet of uniform density ρ has radius R.

Which line, **A** to **D**, in the table gives correct expressions for the mass of the planet and the gravitational field strength at its surface?

	mass of planet	**gravitational field strength at surface**
A	$\frac{4\pi R^2\rho}{3}$	$\frac{4\pi GR\rho}{3}$
B	$\frac{4\pi R^3\rho}{3}$	$\frac{4\pi GR\rho}{3}$
C	$\frac{4\pi R^2\rho}{3}$	$\frac{4\pi G\rho}{3}$
D	$\frac{4\pi R^3\rho}{3}$	$\frac{4\pi G\rho}{3}$

12 The gravitational potential at the surface of the Earth, of radius R, is V. What is the gravitational potential at a point at a height R above the Earth's surface?

A $\frac{V}{4}$

B $\frac{V}{2}$

C V

D $2V$

13 A satellite is in orbit at a height h above the surface of a planet of mass M and radius R. What is the velocity of the satellite?

A $\sqrt{\frac{GM}{(R+h)}}$

B $\frac{\sqrt{GM(R+h)}}{R}$

C $\sqrt{\frac{GM(R+h)}{R}}$

D $\frac{\sqrt{GM}}{(R+h)}$

14 A repulsive force F acts between two positive point charges separated by a distance r. What will be the force between them if each charge is doubled and the distance between them is halved?

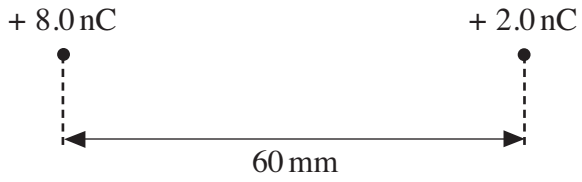
A F

B $2F$

C $4F$

D $16F$

15 The distance between two point charges of + 8.0 nC and + 2.0 nC is 60 mm.



At a point between the charges, on the line joining them, the resultant electric field strength is zero. How far is this point from the + 8.0 nC charge?

A 20 mm

B 25 mm

C 40 mm

D 45 mm

16 Which one of the following **cannot** be used as a unit for electric field strength?

A $J\,m^{-1}\,C^{-1}$

B $J\,A^{-1}\,s^{-1}\,m^{-1}$

C $N\,A^{-1}\,s^{-1}$

D $J\,C\,m^{-1}$

17 A capacitor stores a charge of 600 μC when charged to a potential difference (pd) of 6.0 V. What will be the pd across the plates if the charge stored increases by 50%?

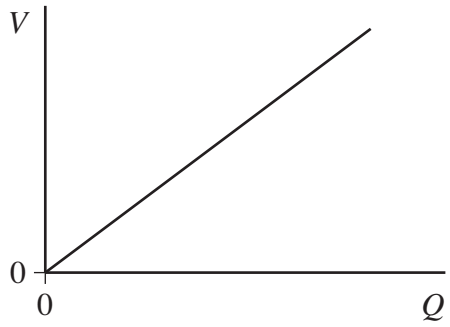
A 3.0 V

B 4.5 V

C 9.0 V

D 12.0 V

18 The graph shows the results of an experiment which was carried out to investigate the relationship between the charge Q stored by a capacitor and the pd V across it.



Which one of the following statements is **not** correct?

A The energy stored can be calculated by finding the area under the line.

B If a capacitor of smaller capacitance had been used the gradient of the graph would be steeper.

C If Q were doubled, the energy stored would be quadrupled.

D The gradient of the graph is equal to the capacitance of the capacitor.

19 A 10 μF capacitor is fully charged to a pd of 3.0 kV. The energy stored in the capacitor can be used to lift a load of 5.0 kg through a vertical height h. What is the approximate value of h?

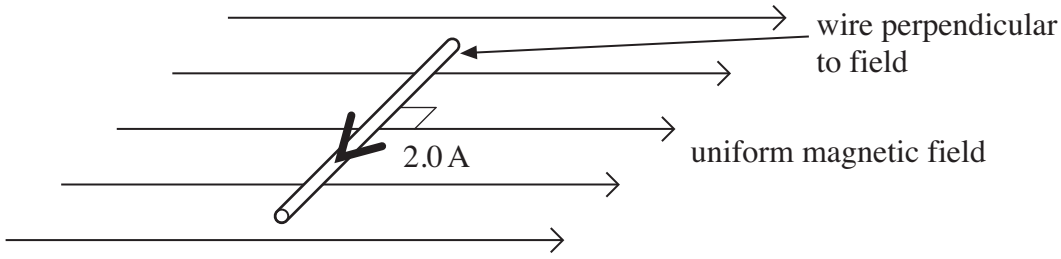
A 0.03 mm

B 0.9 mm

C 0.3 m

D 0.9 m

20 A horizontal straight wire of length 0.30 m carries a current of 2.0 A perpendicular to a horizontal uniform magnetic field of flux density 5.0×10^{-2} T. The wire 'floats' in equilibrium in the field.



What is the mass of the wire?

A 8.0×10^{-4} kg

B 3.1×10^{-3} kg

C 3.0×10^{-2} kg

D 8.2×10^{-1} kg

21 When a β particle moves at right angles through a uniform magnetic field it experiences a force F. An α particle moves at right angles through a magnetic field of twice the magnetic flux density with velocity one tenth the velocity of the β particle. What is the magnitude of the force on the α particle?

A $0.2F$
B $0.4F$
C $0.8F$
D $4.0F$

22 Charged particles, each of mass m and charge Q, travel at a constant speed in a circle of radius r in a uniform magnetic field of flux density B. Which expression gives the frequency of rotation of a particle in the beam?

A $\frac{BQ}{2\pi m}$

B $\frac{BQ}{m}$

C $\frac{BQ}{\pi m}$

D $\frac{2\pi BQ}{m}$

23 A 500 turn coil of cross-sectional area $4.0 \times 10^{-3}\,m^2$ is placed with its plane perpendicular to a magnetic field of flux density $7.5 \times 10^{-4}\,T$. What is the value of the flux linkage for this coil?

A 3.0×10^{-6} Wb turns
B 1.5×10^{-3} Wb turns
C 0.19 Wb turns
D 94 Wb turns

24 The output electromotive force (emf) of a simple ac generator can be increased by any of the four factors listed.

Which one of these factors should **not** be changed if the frequency of the output is to remain unaffected when the emf is increased?

A the area of the coil
B the number of turns on the coil
C the speed of rotation
D the strength of the magnetic field

25 Which one of the following would **not** reduce the energy losses in a transformer?

A using thinner wire for the windings
B using a laminated core instead of a solid core
C using a core made from iron instead of steel
D using a core that allows all the flux due to the primary coil to be linked to the secondary coil

END OF QUESTIONS

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

General Certificate of Education
Advanced Level Examination
January 2012

Physics A PHYA4/2

Unit 4 Fields and Further Mechanics
Section B

Tuesday 24 January 2012 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 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
- 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.
You are advised to spend approximately **one hour** on this section.

1 (a) Define the electric potential at a point in an electric field.

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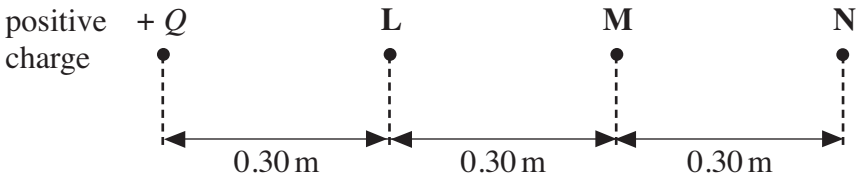
(3 marks)

1 (b) **Figure 1** shows part of the region around a small positive charge.

Figure 1



1 (b) (i) The electric potential at point **L** due to this charge is + 3.0 V. Calculate the magnitude Q of the charge. Express your answer to an appropriate number of significant figures.

answer = ... C

(3 marks)

1 (b) (ii) Show that the electric potential at point **N**, due to the charge, is +1.0 V.

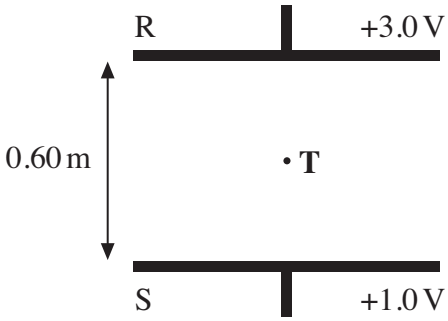
(1 mark)

1 (b) (iii) Show that the electric field strength at point **M**, which is mid-way between **L** and **N**, is 2.5 V m^{-1}.

(1 mark)

1 (c) R and S are two charged parallel plates, 0.60 m apart, as shown in **Figure 2**. They are at potentials of + 3.0 V and + 1.0 V respectively.

Figure 2



1 (c) (i) On **Figure 2**, sketch the electric field between R and S, showing its direction.

(2 marks)

1 (c) (ii) Point **T** is mid-way between R and S.
Calculate the electric field strength at **T**.

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

(1 mark)

1 (c) (iii) Parts (b)(iii) and (c)(ii) both involve the electric field strength at a point mid-way between potentials of + 1.0 V and + 3.0 V. Explain why the magnitudes of these electric field strengths are different.

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(1 mark)

12

2 (a) Define the capacitance of a capacitor.

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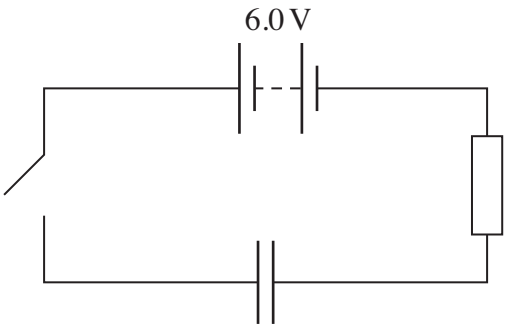
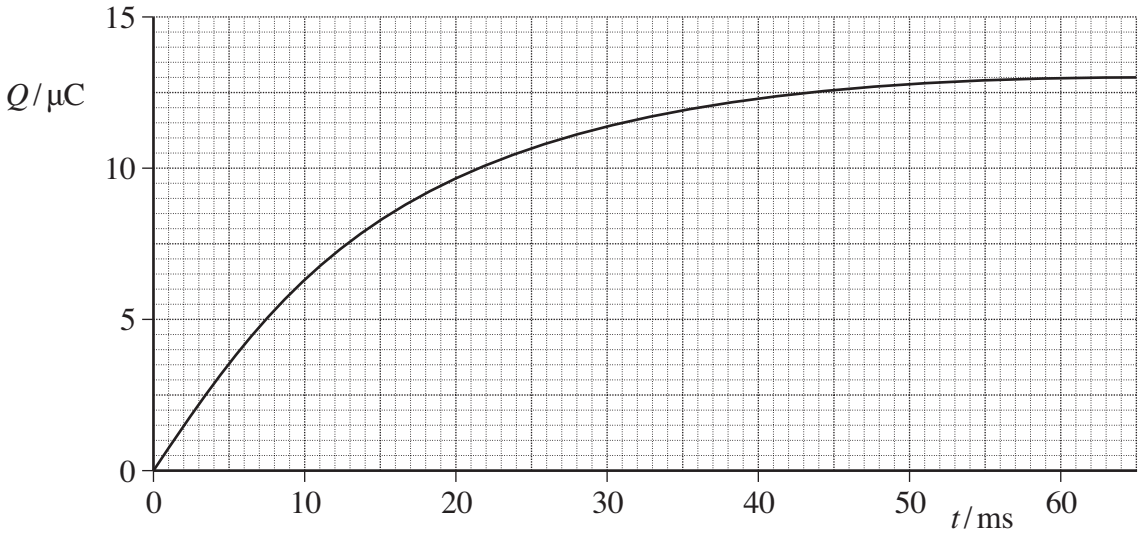
(2 marks)

2 (b) The circuit shown in **Figure 3** contains a battery, a resistor, a capacitor and a switch.

Figure 3



The switch in the circuit is closed at time $t = 0$. The graph shows how the charge Q stored by the capacitor varies with t.



2 (b) (i) When the capacitor is fully charged, the charge stored is 13.2 μC. The electromotive force (emf) of the battery is 6.0 V. Determine the capacitance of the capacitor.

answer = ... F

(2 marks)

2 (b) (ii) The time constant for this circuit is the time taken for the charge stored to increase from 0 to 63% of its final value. Use the graph to find the time constant in milliseconds.

answer = ... ms

(2 marks)

2 (b) (iii) Hence calculate the resistance of the resistor.

answer = ... Ω

(1 mark)

2 (b) (iv) What physical quantity is represented by the gradient of the graph?

.....

.....

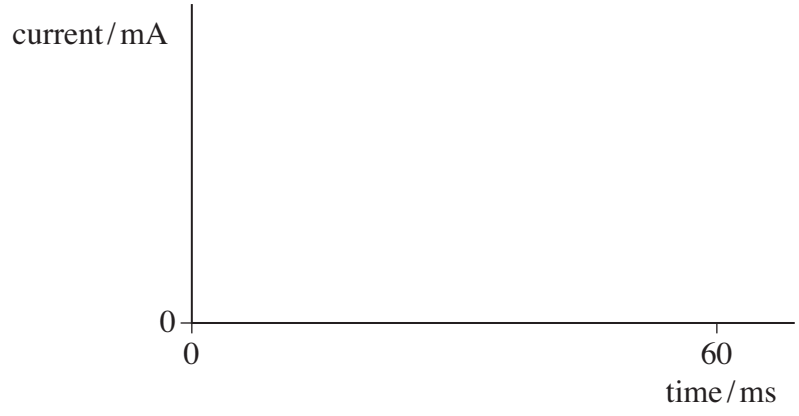
(1 mark)

2 (c) (i) Calculate the maximum value of the current, in mA, in this circuit during the charging process.

answer = ... mA

(1 mark)

2 (c) (ii) Sketch a graph on the outline axes to show how the current varies with time as the capacitor is charged. Mark the maximum value of the current on your graph.

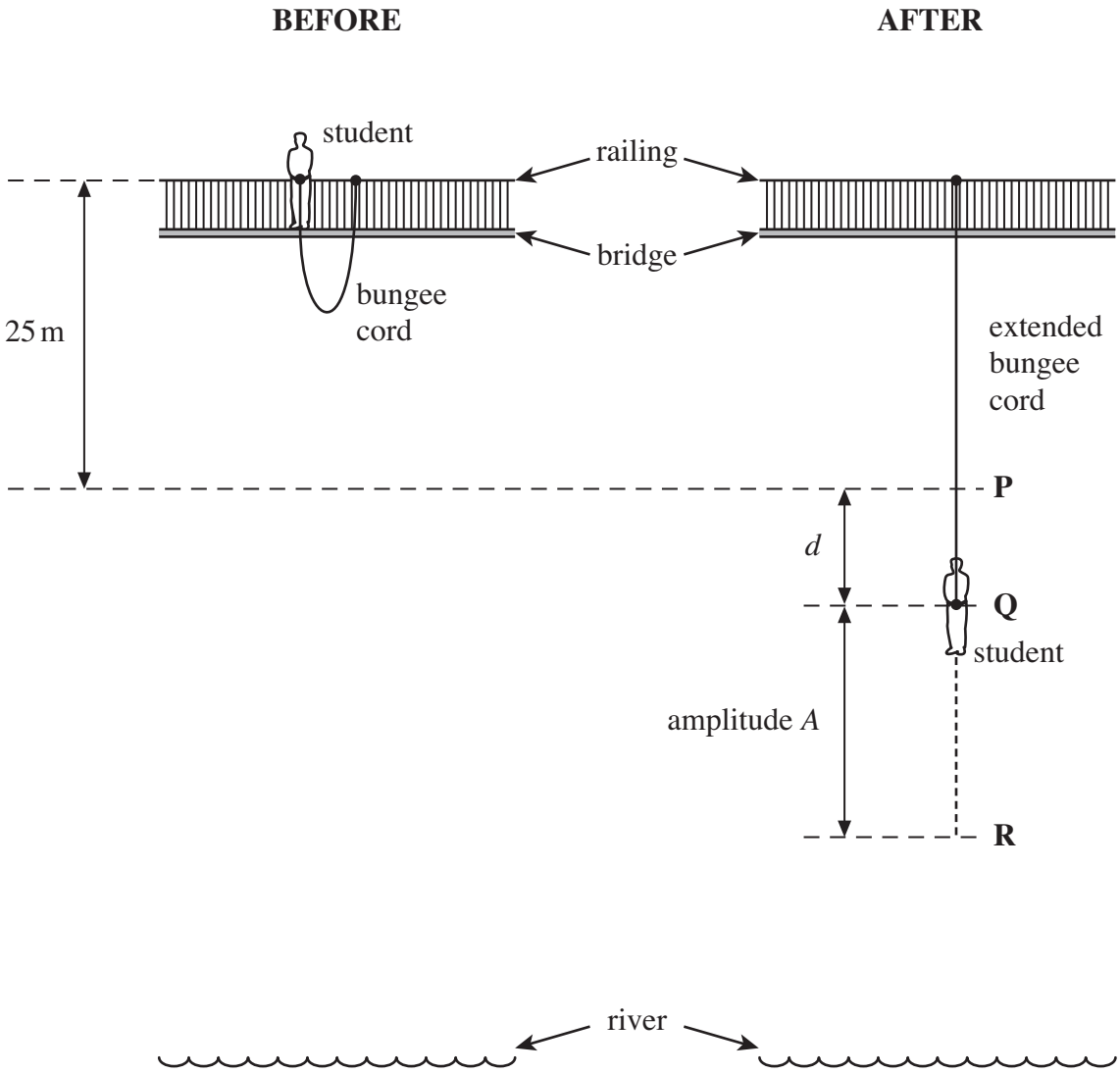


(2 marks)

11

3 The two diagrams in **Figure 4** show a student before and after she makes a bungee jump from a high bridge above a river. One end of the bungee cord, which is of unstretched length 25 m, is fixed to the top of a railing on the bridge. The other end of the cord is attached to the waist of the student, whose mass is 58 kg. After she jumps, the bungee cord goes into tension at point **P**. She comes to rest momentarily at point **R** and then oscillates about point **Q**, which is a distance *d* below **P**.

Figure 4



3 (a) (i) Assuming that the centre of mass of the student has fallen through a vertical distance of 25 m when she reaches point **P**, calculate her speed at **P**.
You may assume that air resistance is negligible.

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

(2 marks)

3 (a) (ii) The bungee cord behaves like a spring of spring constant 54 $N\,m^{-1}$.
Calculate the distance d, from **P** to **Q**, assuming the cord obeys Hooke's law.

answer = ... m

(2 marks)

3 (b) As the student moves below **P**, she begins to move with simple harmonic motion for part of an oscillation.

3 (b) (i) If the arrangement can be assumed to act as a mass-spring system, calculate the time taken for one half of an oscillation.

answer = ... s

(2 marks)

3 (b) (ii) Use your answers from parts (a) and (b)(i) to show that the amplitude A, which is the distance from **Q** to **R**, is about 25 m.

(3 marks)

Turn over ▶

3 (c) Explain why, when the student rises above point **P**, her motion is no longer simple harmonic.

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(2 marks)

3 (d) (i) Where is the student when the stress in the bungee cord is a maximum?

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(1 mark)

3 (d) (ii) The bungee cord has a significant mass. Whereabouts along the bungee cord is the stress a maximum? Explain your answer.

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(2 marks)

14

4 (a) A transformer operating on a 230 V mains supply provides a 12 V output. There are 1150 turns on the primary coil.

4 (a) (i) Calculate the number of turns on the secondary coil.

answer = ... turns
(1 mark)

4 (a) (ii) A number of identical lamps rated at 12 V, 24 W are connected in parallel across the secondary coil. The primary circuit of the transformer includes a 630 mA fuse. Calculate the maximum number of lamps that can be supplied by the transformer if its efficiency is 85%.

answer = ... lamps
(2 marks)

4 (a) (iii) The transformer circuit includes a fuse. Explain why this is necessary.

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(1 mark)

4 (a) (iv) Why is the fuse placed in the primary circuit rather than in the secondary circuit?

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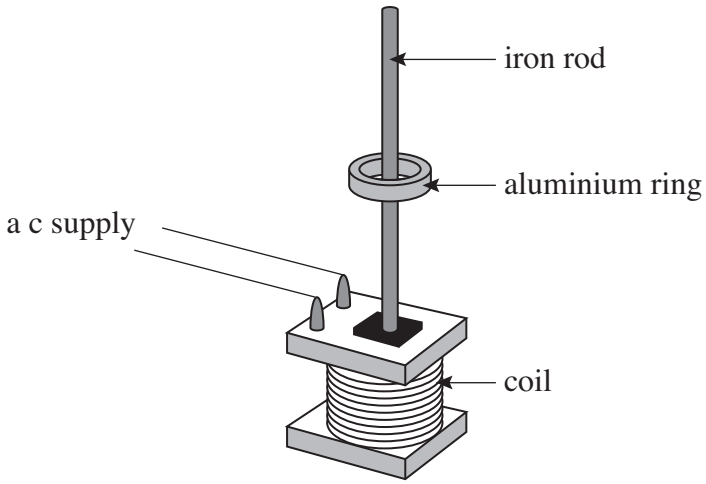
(1 mark)

Question 4 continues on the next page

4 (b) **Figure 5** shows an experimental arrangement that can be used to demonstrate magnetic levitation. The iron rod is fixed vertically inside a large coil of wire. When the alternating current supply to the coil is switched on, the aluminium ring moves up the rod until it reaches a stable position 'floating' above the coil.

Figure 5



4 (b) (i) By reference to the laws of electromagnetic induction explain

- why a current will be induced in the ring,
- why the ring experiences a force that moves it upwards,
- why the ring reaches a stable position.

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

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(6 marks)

4 (b) (ii) What would happen to the ring if the alternating current in the coil was increased without changing the frequency? Explain your answer.

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(2 marks)

13

END OF QUESTIONS

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