Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

General Certificate of Education
Advanced Level Examination
June 2014

Physics A PHYA4/1

Unit 4 Fields and Further Mechanics
Section A

Wednesday 11 June 2014 1.30 pm to 3.15 pm

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.

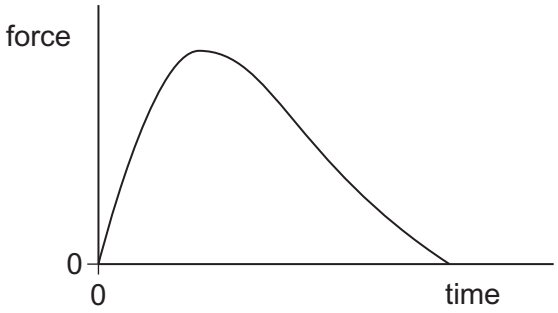
Information
- The maximum mark for this section is 25.
- All questions in Section A carry equal marks. No deductions will be made for incorrect answers.
- A *Data and Formulae Booklet* is provided as a loose insert.
- The question paper/answer book for Section B is enclosed within this question paper.

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 The graph shows how the force acting on a rocket varies with time.



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

A distance travelled

B gain in kinetic energy

C change in velocity

D change in momentum

2 A golf club strikes a stationary golf ball of mass $4.8 \times 10^{-2}\,\text{kg}$ and the ball leaves the club with a speed of $95\,\text{m s}^{-1}$. If the average force exerted on the ball is $7800\,\text{N}$, how long are the ball and club in contact?

A $5.8 \times 10^{-4}\,\text{s}$

B $1.2 \times 10^{-2}\,\text{s}$

C $0.51\,\text{s}$

D $0.58\,\text{s}$

3 Water of density $1000\,\text{kg m}^{-3}$ flows out of a garden hose of cross-sectional area $7.2 \times 10^{-4}\,\text{m}^2$ at a rate of $2.0 \times 10^{-4}\,\text{m}^3$ per second. How much momentum is carried by the water leaving the hose per second?

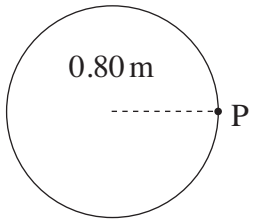
A $5.6 \times 10^{-5}\,\text{N s}$

B $5.6 \times 10^{-2}\,\text{N s}$

C $0.20\,\text{N s}$

D $0.72\,\text{N s}$

4 A model car moves in a circular path of radius $0.80\,\text{m}$ at an angular speed of $\frac{\pi}{2}\,\text{rad}\,\text{s}^{-1}$.



What is its displacement from point P $6.0\,\text{s}$ after passing P?

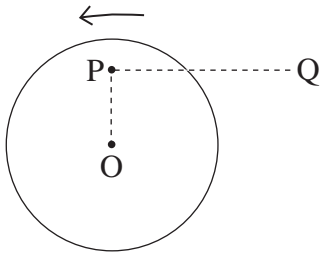
A zero

B $0.4\pi\,\text{m}$

C $1.6\,\text{m}$

D $1.6\pi\,\text{m}$

5 A small mass is placed at P on a horizontal disc which has its centre at O. The disc rotates anti-clockwise about a vertical axis through O with constant angular speed.



Which one of the following describes the force which keeps the mass at rest relative to the disc when in the position shown?

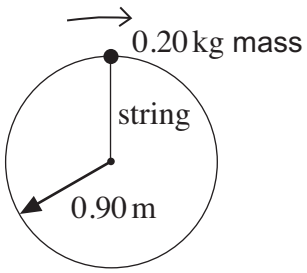
A the weight of the mass

B a frictional force from P to Q

C a frictional force directed away from O

D a frictional force directed towards O

6 A $0.20\,\text{kg}$ mass is whirled round in a vertical circle on the end of a light string of length $0.90\,\text{m}$.



At the top point of the circle the speed of the mass is $8.2\,\text{m s}^{-1}$. What is the tension in the string at this point?

A $10\,\text{N}$

B $13\,\text{N}$

C $17\,\text{N}$

D $20\,\text{N}$

7 Which line, **A** to **D**, in the table gives the amplitude and frequency of a body performing simple harmonic motion whose displacement x at time t is given by the equation $x = P\cos Qt$?

	Amplitude	Frequency
A	$\frac{P}{2}$	$\frac{Q}{2\pi}$
B	P	$2\pi Q$
C	P	$\frac{Q}{2\pi}$
D	$2P$	$\frac{Q}{2\pi}$

8 The tip of each prong of a tuning fork emitting a note of $320\,\text{Hz}$ vibrates in simple harmonic motion with an amplitude of $0.50\,\text{mm}$.
What is the speed of each tip when its displacement is zero?

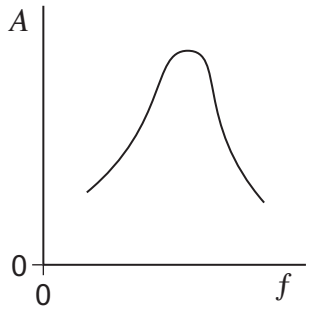
A zero

B $0.32\pi\ \text{mm s}^{-1}$

C $160\pi\ \text{mm s}^{-1}$

D $320\pi\ \text{mm s}^{-1}$

9 A periodic force is applied to a lightly-damped object causing the object to oscillate. The graph shows how the amplitude A of the oscillations varies with the frequency f of the periodic force.



Which one of the following statements best describes how the shape of the curve would differ if the damping had been greater?

A The curve would be lower at all frequencies.

B The curve would be higher at all frequencies.

C The curve would be unchanged except at frequencies above the resonant frequency where it would be lower.

D The curve would be unchanged except at frequencies above the resonant frequency where it would be higher.

10 A spacecraft of mass m is at the mid-point between the centres of a planet of mass M_1 and its moon of mass M_2. If the distance between the spacecraft and the centre of the planet is d, what is the magnitude of the resultant gravitational force on the spacecraft?

A $\dfrac{Gm(M_1 - M_2)}{d}$

B $\dfrac{Gm(M_1 + M_2)}{d^2}$

C $\dfrac{Gm(M_1 - M_2)}{d^2}$

D $\dfrac{Gm(M_1 + M_2)}{d}$

11 Which one of the following statements about gravitational potential is correct?

A Gravitational potential can have a positive value.

B The gravitational potential at the surface of the Earth is zero.

C The gravitational potential gradient at a point has the same numerical value as the gravitational field strength at that point.

D The unit of gravitational potential is $\mathrm{N\,kg^{-1}}$.

12 Which one of the following statements is correct?

The force between two charged particles

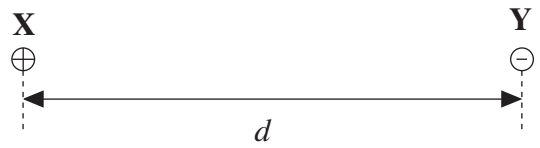
A is always attractive.

B can be measured in $\mathrm{C^2\,F^{-1}\,m^{-1}}$.

C is directly proportional to the distance between them.

D is independent of the magnitude of the charges.

13 Two point charges, **X** and **Y**, exert a force F on each other when they are at a distance d apart.



When the distance between them is $20\,\mathrm{mm}$, the force they exert on each other is $0.5\,F$.

What is the distance d?

A $7\,\mathrm{mm}$

B $14\,\mathrm{mm}$

C $15\,\mathrm{mm}$

D $28\,\mathrm{mm}$

14 Which one of the following statements is correct?

When a negative ion is projected into an electric field

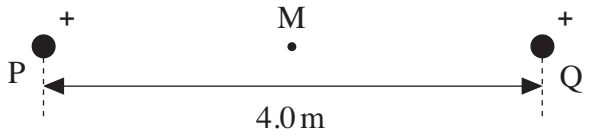
A the field can change the magnitude of the velocity but not its direction.

B the field can change the direction of the velocity but not its magnitude.

C the field can change both the magnitude and the direction of the velocity.

D the ion will accelerate in the direction of the field.

15 Two identical positive point charges, P and Q, are separated by a distance of $4.0\,\text{m}$. The resultant electric potential at point M, which is mid-way between the charges, is $25.0\,\text{V}$.



What would be the resultant electrical potential at a point $1.0\,\text{m}$ closer to P?

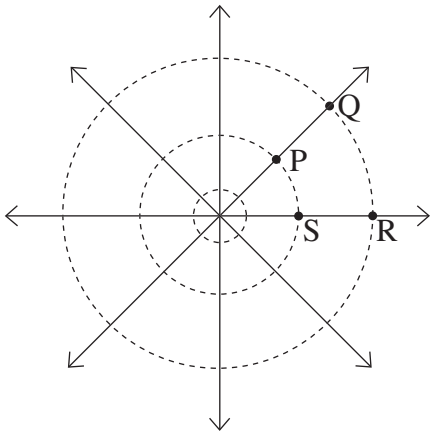
A $8.3\,\text{V}$

B $12.5\,\text{V}$

C $33.3\,\text{V}$

D $37.5\,\text{V}$

16 The diagram below shows the field lines and equipotential lines around an isolated positive point charge.



Which one of the following statements concerning the work done when a small charge is moved in the field is **incorrect**?

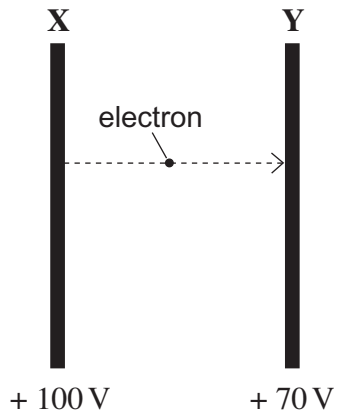
A When it is moved from either P to Q or S to R, the work done is the same in each case.

B When it is moved from Q to R no work is done.

C When it is moved around the path PQRS, the overall work done is zero.

D When it is moved around the path PQRS, the overall work done is equal to twice the work done in moving from P to Q.

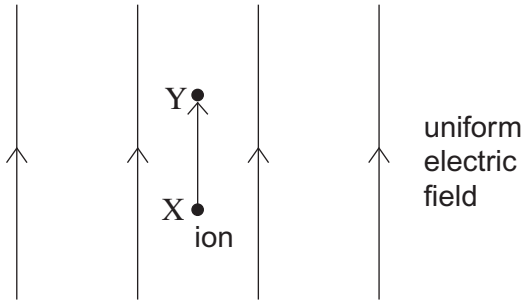
17 Two fixed parallel metal plates **X** and **Y** are at constant potentials of + 100 V and + 70 V respectively. An electron travelling from **X** to **Y** experiences a change of potential energy ΔE_p



Which line, **A** to **D**, in the table shows correctly the direction of the electrostatic force F on the electron and the value of ΔE_p?

	Direction of F	**ΔE_p**
A	towards **X**	+ 30 eV
B	towards **Y**	– 30 eV
C	away from **X**	+ 30 eV
D	away from **Y**	– 30 eV

18 A uniform electric field of electric field strength E is aligned so it is vertical. An ion moves vertically through a small distance Δd from point X to point Y in the field. There is a uniform gravitational field of field strength g throughout the region.



Which line, **A** to **D**, in the table correctly gives the gravitational potential difference, and the electric potential difference, between X and Y?

	Gravitational potential difference	**Electric potential difference**
A	$g\Delta d$	$E\Delta d$
B	$g\Delta d$	$\frac{E}{\Delta d}$
C	$\frac{g}{\Delta d}$	$E\Delta d$
D	$\frac{g}{\Delta d}$	$\frac{E}{\Delta d}$

19 Initially a charged capacitor stores $1600\,\mu J$ of energy. When the pd across it decreases by $2.0\,V$, the energy stored by it becomes $400\,\mu J$.

What is the capacitance of this capacitor?

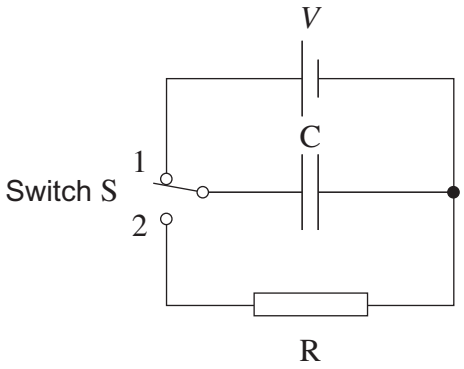
A $100\,\mu F$

B $200\,\mu F$

C $400\,\mu F$

D $600\,\mu F$

20 Switch S in the circuit is held in position 1, so that the capacitor C becomes fully charged to a pd V and stores energy E.



The switch is then moved quickly to position 2, allowing C to discharge through the fixed resistor R. It takes 36 ms for the pd across C to fall to $\frac{V}{2}$. What period of time must elapse, after the switch has moved to position 2, before the energy stored by C has fallen to $\frac{E}{16}$?

A 51 ms

B 72 ms

C 432 ms

D 576 ms

21 The path followed by an electron of momentum p, carrying charge $-e$, which enters a magnetic field at right angles, is a circular arc of radius r.

What would be the radius of the circular arc followed by an α particle of momentum $2p$, carrying charge $+2e$, which entered the same field at right angles?

A $\frac{r}{2}$

B r

C $2r$

D $4r$

22 In which one of the following applications does electromagnetic induction **not** take place?

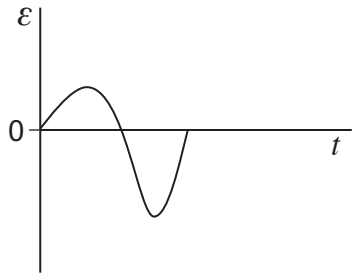
A the generators at a nuclear power station

B the ac power adapter for a laptop computer

C the wings of an aircraft cutting through the Earth's magnetic field

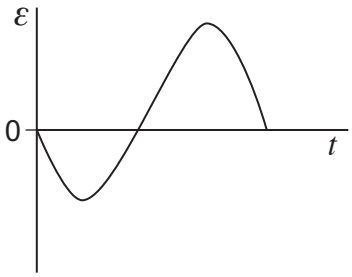
D the back up capacitor of an electric timer

23 When a magnet is dropped through an aluminium ring an emf is induced. A data logger connected to the ring records the variation of the induced emf ε with time t as shown below.

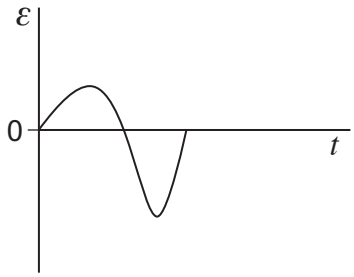


In a second experiment, the magnet is dropped from a greater height.

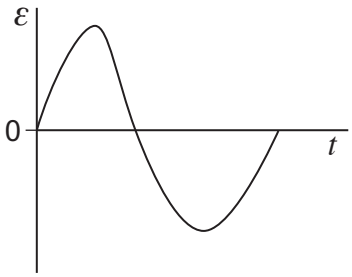
Which one of the following graphs best represents the induced emf in the second experiment?



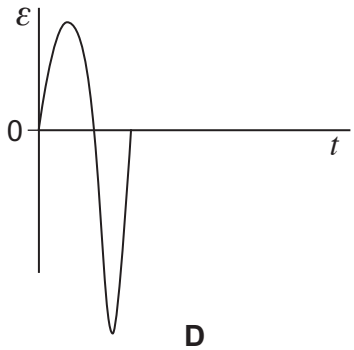
A



B



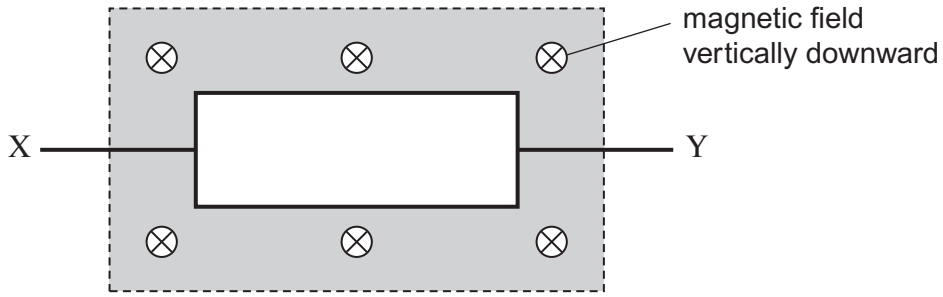
C



D

24 A rectangular coil of area A has N turns of wire. The coil is in a uniform magnetic field, as shown in the diagram.

When the coil is rotated at a constant frequency f about its axis XY, an alternating emf of peak value ε_0 is induced in it.



What is the maximum value of the magnetic flux linkage through the coil?

A $\dfrac{\varepsilon_0}{2\pi f}$

B $\dfrac{\varepsilon_0}{\pi f}$

C $\pi f \varepsilon_0$

D $2\pi f \varepsilon_0$

25 A transformer has 1150 turns on the primary coil and 500 turns on the secondary coil. The primary coil draws a current of $0.26\,\text{A}$ from a $230\,\text{V}$ ac supply. The current in the secondary coil is $0.50\,\text{A}$. What is the efficiency of the transformer?

A 42%

B 50%

C 84%

D 100%

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	
TOTAL	

General Certificate of Education
Advanced Level Examination
June 2014

Physics A PHYA4/2

Unit 4 Fields and Further Mechanics
Section B

Wednesday 11 June 2014 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 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.

Section B

Answer **all** questions in the spaces provided.

1 (a) (i) Define gravitational field strength and state whether it is a scalar or vector quantity.

[2 marks]

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1 (a) (ii) A mass m is at a height h above the surface of a planet of mass M and radius R. The gravitational field strength at height h is g. By considering the gravitational force acting on mass m, derive an equation from Newton's law of gravitation to express g in terms of M, R, h and the gravitational constant G.

[2 marks]

1 (b) (i) A satellite of mass $2520\,\text{kg}$ is at a height of $1.39 \times 10^7\,\text{m}$ above the surface of the Earth. Calculate the gravitational force of the Earth attracting the satellite. Give your answer to an appropriate number of significant figures.

[3 marks]

force attracting satellite ..... N

1 (b) (ii) The satellite in part (b)(i) is in a circular polar orbit. Show that the satellite would travel around the Earth three times every 24 hours.

[5 marks]

1 (c) State and explain **one** possible use for the satellite travelling in the orbit in part (b)(ii).

[2 marks]

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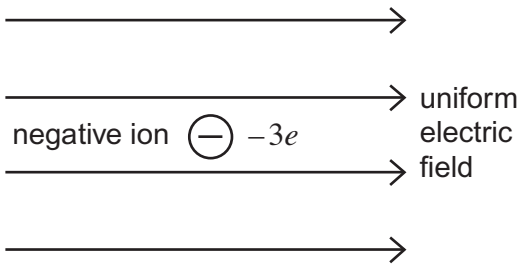
14

2 (a) **Figure 1** shows a negative ion which has a charge of $-3e$ and is free to move in a uniform electric field. When the ion is accelerated by the field through a distance of $63\,\text{mm}$ parallel to the field lines its kinetic energy increases by $4.0 \times 10^{-16}\,\text{J}$.

Figure 1



2 (a) (i) State and explain the direction of the electrostatic force on the ion.

[2 marks]

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2 (a) (ii) Calculate the magnitude of the electrostatic force acting on the ion.

[2 marks]

magnitude of electrostatic force ..... N

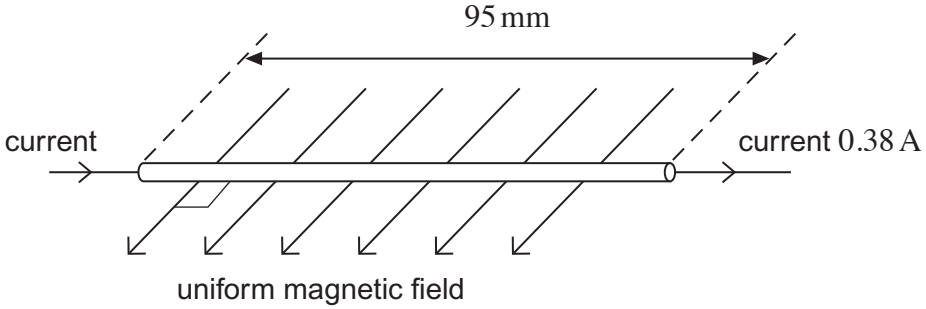
2 (a) (iii) Calculate the electric field strength.

[1 mark]

electric field strength ..... N C^{-1}

2 (b) **Figure 2** shows a section of a horizontal copper wire carrying a current of $0.38\,\text{A}$. A horizontal uniform magnetic field of flux density B is applied at right angles to the wire in the direction shown in the figure.

Figure 2



2 (b) (i) State the direction of the magnetic force that acts on the moving electrons in the wire as a consequence of the current and explain how you arrive at your answer.

[2 marks]

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2 (b) (ii) Copper contains 8.4×10^{28} free electrons per cubic metre. The section of wire in **Figure 2** is $95\,\text{mm}$ long and its cross-sectional area is $5.1 \times 10^{-6}\,\text{m}^2$. Show that there are about 4×10^{22} free electrons in this section of wire.

[1 mark]

2 (b) (iii) With a current of $0.38\,\text{A}$, the average velocity of an electron in the wire is $5.5 \times 10^{-6}\,\text{m s}^{-1}$ and the average magnetic force on one electron is $1.4 \times 10^{-25}\,\text{N}$. Calculate the flux density B of the magnetic field.

[2 marks]

flux density ..... T

10

3 (a) (i) Name the **two** types of potential energy involved when a mass–spring system performs vertical simple harmonic oscillations.

[1 mark]

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3 (a) (ii) Describe the energy changes which take place during one complete oscillation of a vertical mass-spring system, starting when the mass is at its lowest point.

[2 marks]

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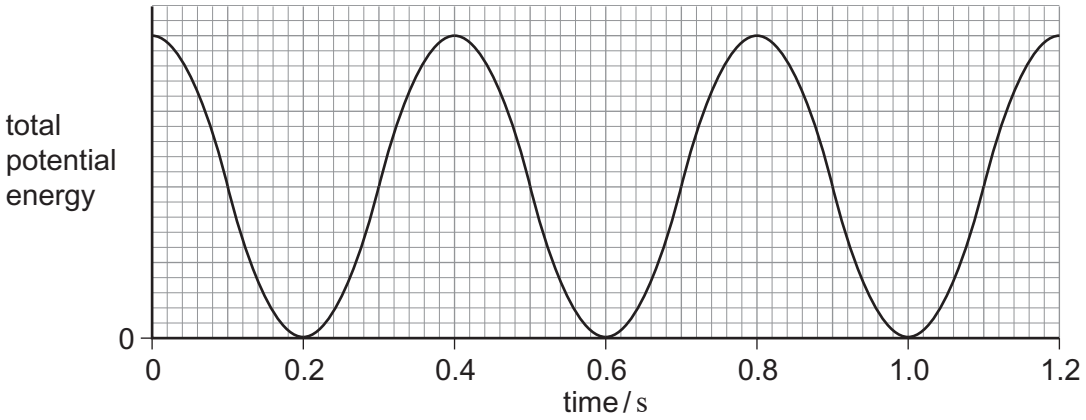
3 (b) **Figure 3** shows how the **total** potential energy due to the simple harmonic motion varies with time when a mass-spring system oscillates vertically.

Figure 3



3 (b) (i) State the time period of the simple harmonic oscillations that produces the energy–time graph shown in **Figure 3**, explaining how you arrive at your answer.

[2 marks]

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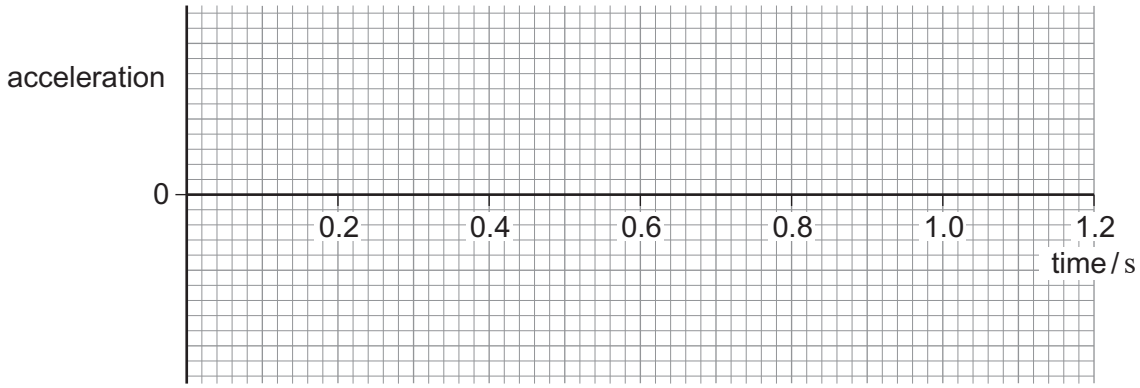
3 (b) (ii) Sketch a graph on **Figure 4** to show how the acceleration of the mass varies with time over a period of $1.2\,\mathrm{s}$, starting with the mass at the highest point of its oscillations. On your graph, upwards acceleration should be shown as positive and downwards acceleration as negative. Values are not required on the acceleration axis.

[2 marks]

Figure 4



3 (c) (i) The mass of the object suspended from the spring in part (b) is $0.35\,\mathrm{kg}$. Calculate the spring constant of the spring used to obtain **Figure 3**. State an appropriate unit for your answer.

[3 marks]

spring constant ..... unit .....

3 (c) (ii) The maximum kinetic energy of the oscillating object is $2.0 \times 10^{-2}\,\mathrm{J}$. Show that the amplitude of the oscillations of the object is about $40\,\mathrm{mm}$.

[4 marks]

14

4 (a) When an uncharged capacitor is charged by a **constant** current of $4.5\,\mu A$ for $60\,s$ the pd across it becomes $4.4\,V$.

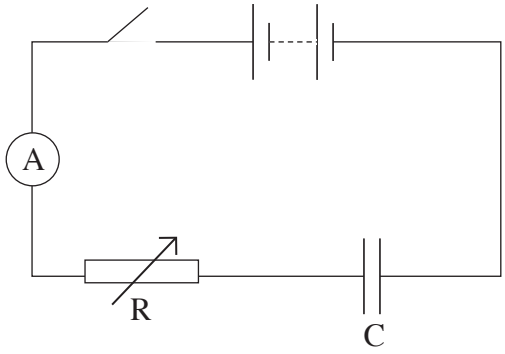
4 (a) (i) Calculate the capacitance of the capacitor.

[3 marks]

capacitance ..... F

4 (a) (ii) The capacitor is charged using the circuit shown in **Figure 5**. The battery emf is $6.0\,V$ and its internal resistance is negligible. In order to keep the current constant at $4.5\,\mu A$, the resistance of the variable resistor R is decreased steadily as the charge on the capacitor increases.

Figure 5



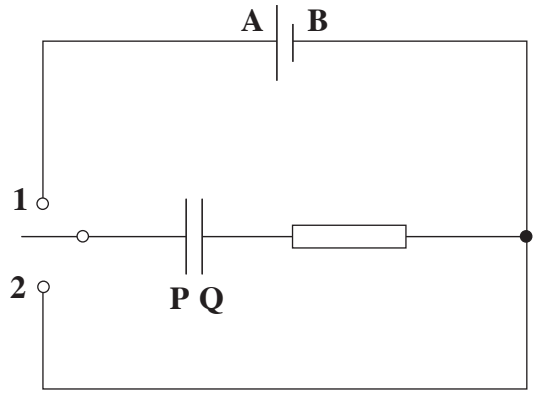
Calculate the resistance of R when the uncharged capacitor has been charging for $30\,s$.

[3 marks]

resistance ..... Ω

4 (b) The circuit in **Figure 6** contains a cell, an uncharged capacitor, a fixed resistor and a two-way switch.

Figure 6



The switch is moved to position **1** until the capacitor is fully charged. The switch is then moved to position **2**.

Describe what happens in this circuit after the switch is moved to position **1**, and after it has been moved to position **2**. In your answer you should refer to:

- the direction in which electrons flow in the circuit, and how the flow of electrons changes with time,
- how the potential differences across the resistor and the capacitor change with time,
- the energy changes which take place in the circuit.

The terminals of the cell are labelled **A** and **B** and the capacitor plates are labelled **P** and **Q** so that you can refer to them in your answer.

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

[6 marks]

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END OF QUESTIONS

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