Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

General Certificate of Education
Advanced Level Examination
June 2012

Physics A — PHYA4/1

Unit 4 Fields and Further Mechanics
Section A

Monday 11 June 2012 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.

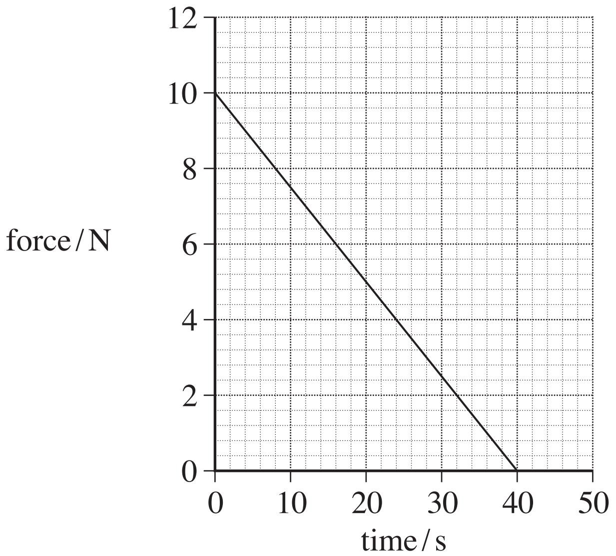
Information
- The maximum mark for this section is 25.
- All questions in Section A carry equal marks. No deductions will be made for incorrect answers.
- A *Data and Formulae Booklet* is provided as a loose insert.
- The question paper/answer book for Section B is enclosed within this question paper.

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 approximately **45 minutes** on this section.

1 The graph shows how the force acting on a body changes with time.



The body has a mass of 0.25 kg and is initially at rest. What is the speed of the body after 40 s assuming no other forces are acting?

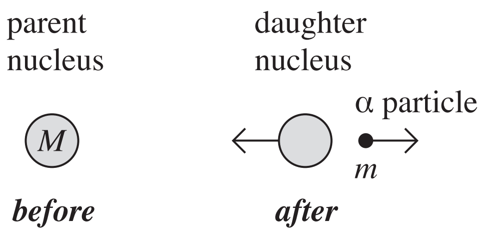
A $200\,\text{m}\,\text{s}^{-1}$

B $400\,\text{m}\,\text{s}^{-1}$

C $800\,\text{m}\,\text{s}^{-1}$

D $1600\,\text{m}\,\text{s}^{-1}$

2 A stationary unstable nucleus of mass M emits an α particle of mass m with kinetic energy E.



What is the speed of recoil of the daughter nucleus?

A $\dfrac{\sqrt{2mE}}{(M-m)}$

B $\dfrac{\sqrt{2mE}}{M}$

C $\dfrac{(M-m)}{\sqrt{2mE}}$

D $\dfrac{2mE}{(M-m)^2}$

3 Two ice skaters, initially at rest and in contact, push apart from each other.
Which line, **A** to **D**, in the table states correctly the change in the total momentum and the total kinetic energy of the two skaters?

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

4 The Earth moves around the Sun in a circular orbit with a radius of 1.5×10^8 km.
What is the Earth's approximate speed?

A $1.5 \times 10^3\,\mathrm{m\,s^{-1}}$

B $5.0 \times 10^3\,\mathrm{m\,s^{-1}}$

C $1.0 \times 10^4\,\mathrm{m\,s^{-1}}$

D $3.0 \times 10^4\,\mathrm{m\,s^{-1}}$

5 A particle moves in a circular path at constant speed. Which one of the following statements is correct?

A The velocity of the particle is directed towards the centre of the circle.

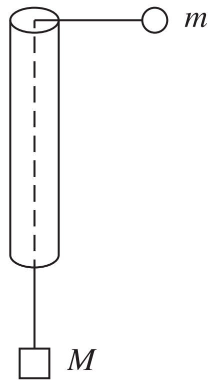
B There is no force acting on the particle.

C There is no change in the kinetic energy of the particle.

D The particle has an acceleration directed along a tangent to the circle.

Turn over ▶

6 The diagram shows a smooth thin tube through which passes a string with masses m and M attached to its ends. The tube is moved so that the mass m travels in a horizontal circle of constant radius r at constant speed v.



Which one of the following expressions is equal to M?

A $\frac{mv^2}{2r}$

B mv^2rg

C $\frac{mv^2}{rg}$

D $\frac{mv^2g}{r}$

7 A mass on the end of a spring undergoes vertical simple harmonic motion. At which point(s) is the magnitude of the resultant force on the mass a minimum?

A at the centre of the oscillation
B only at the top of the oscillation
C only at the bottom of the oscillation
D at both the top and bottom of the oscillation

8 A baby bouncer consisting of a harness and elastic ropes is suspended from a doorway. When a baby of mass 10 kg is placed in the harness, the ropes stretch by 0.25 m. When the baby bounces, she starts to move with vertical simple harmonic motion. What is the time period of her motion?

A 1.0 s
B 2.1 s
C 2.3 s
D 3.1 s

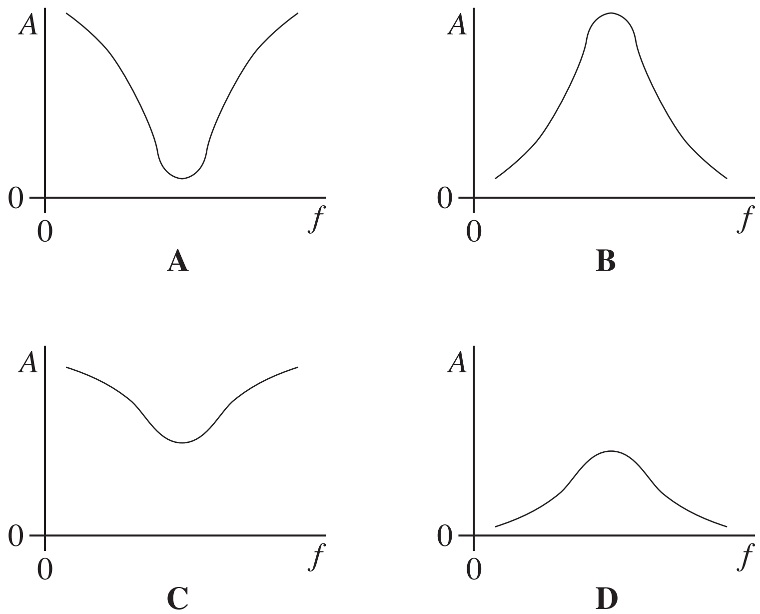
Do not write outside the box

9 A simple pendulum and a mass-spring system both have the same time period T at the surface of the Earth. If taken to another planet where the acceleration due to gravity is twice that on Earth, which line, **A** to **D**, in the table gives the correct new time periods?

	simple pendulum	**mass-spring**
A	$T\sqrt{2}$	$\frac{T}{\sqrt{2}}$
B	$T\sqrt{2}$	T
C	$\frac{T}{\sqrt{2}}$	T
D	$\frac{T}{\sqrt{2}}$	$T\sqrt{2}$

10 An oscillatory system, subject to damping, is set into vibration by a periodic driving force of frequency f. The graphs, **A** to **D**, which are to the same scale, show how the amplitude of vibration A of the system might vary with f, for various degrees of damping.

Which graph best shows the lightest damping?



11 Which one of the following statements about gravitational fields is **incorrect**?

A Moving a mass in the direction of the field lines reduces its potential energy.

B A stronger field is represented by a greater density of field lines.

C Moving a mass perpendicularly across the field lines does not alter its potential energy.

D At a distance r from a mass the field strength is inversely proportional to r.

Turn over ▶

12 An object on the surface of a planet of radius R and mass M has weight W.
What would be the weight of the same object when on the surface of a planet of radius $2R$ and mass $2M$?

A $\frac{W}{4}$

B $\frac{W}{2}$

C W

D $2W$

13 The gravitational field strength on the surface of a planet orbiting a star is $8.0\,\text{N kg}^{-1}$.
If the planet and star have a similar density but the diameter of the star is 100 times greater than the planet, what would be the gravitational field strength at the surface of the star?

A $0.0008\,\text{N kg}^{-1}$

B $0.08\,\text{N kg}^{-1}$

C $800\,\text{N kg}^{-1}$

D $8000\,\text{N kg}^{-1}$

14 Two satellites, P and Q, of the same mass, are in circular orbits around the Earth. The radius of the orbit of Q is three times that of P. Which one of the following statements is correct?

A The kinetic energy of P is greater than that of Q.

B The weight of P is three times that of Q.

C The time period of P is greater than that of Q.

D The speed of P is three times that of Q.

15 The force between two point charges is F when they are separated by a distance r.
If the separation is increased to $3r$, what is the force between the charges?

A $\frac{F}{3r}$

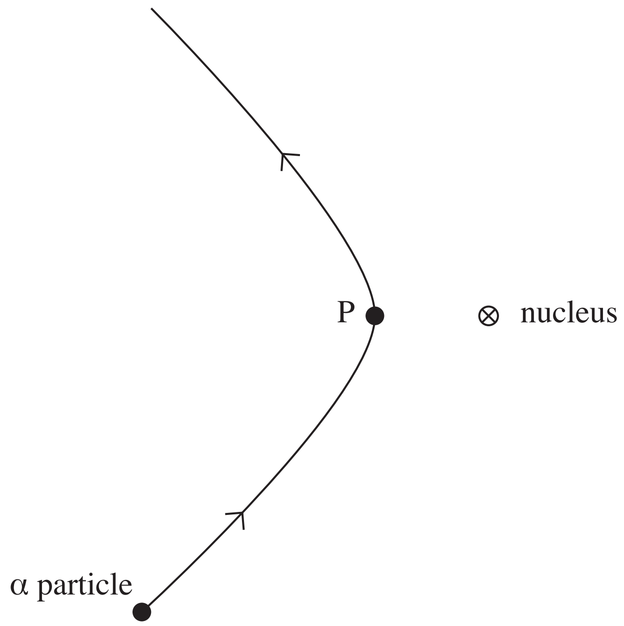
B $\frac{F}{9r}$

C $\frac{F}{3}$

D $\frac{F}{9}$

Do not write outside the box

16 The diagram shows the path of an α particle deflected by the nucleus of an atom. Point P on the path is the point of closest approach of the α particle to the nucleus.



Which one of the following statements about the α particle on this path is correct?

A Its acceleration is zero at P.

B Its kinetic energy is greatest at P.

C Its speed is least at P.

D Its potential energy is least at P.

17 A 1000 μF capacitor and a 10 μF capacitor are charged so that they store the same energy. The pd across the 1000 μF capacitor is V_1 and the pd across the other capacitor is V_2.

What is the value of the ratio $\left(\frac{V_1}{V_2}\right)^2$?

A $\frac{1}{1000}$

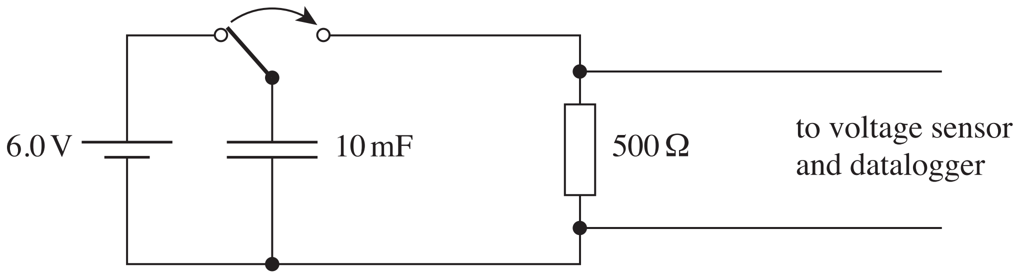
B $\frac{1}{100}$

C $\frac{1}{10}$

D 10

Turn over ▶

18 A voltage sensor and a datalogger are used to record the discharge of a 10 mF capacitor in series with a 500 Ω resistor from an initial pd of 6.0 V. The datalogger is capable of recording 1000 readings in 10 s. Which line, **A** to **D**, in the table gives the pd and the number of readings made after a time equal to the time constant of the discharge circuit?



	potential difference/V	**number of readings**
A	2.2	50
B	3.8	50
C	3.8	500
D	2.2	500

19 When a 220 μF capacitor is discharged through a resistor R, the capacitor pd decreases from 6.0 V to 1.5 V in 92 s.

What is the resistance of R?

A 210 kΩ

B 300 kΩ

C 420 kΩ

D 440 kΩ

20 A section of current-carrying wire is placed at right angles to a uniform magnetic field of flux density B. When the current in the wire is I, the magnetic force that acts on this section is F.

What force acts when the same section of wire is placed at right angles to a uniform magnetic field of flux density $2B$ when the current is $0.25I$?

A $\frac{F}{4}$

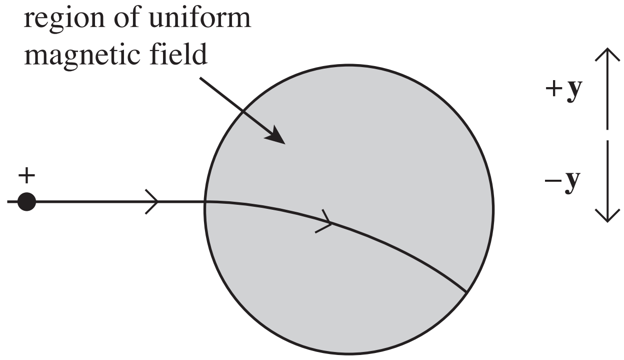
B $\frac{F}{2}$

C F

D $2F$

Do not write outside the box

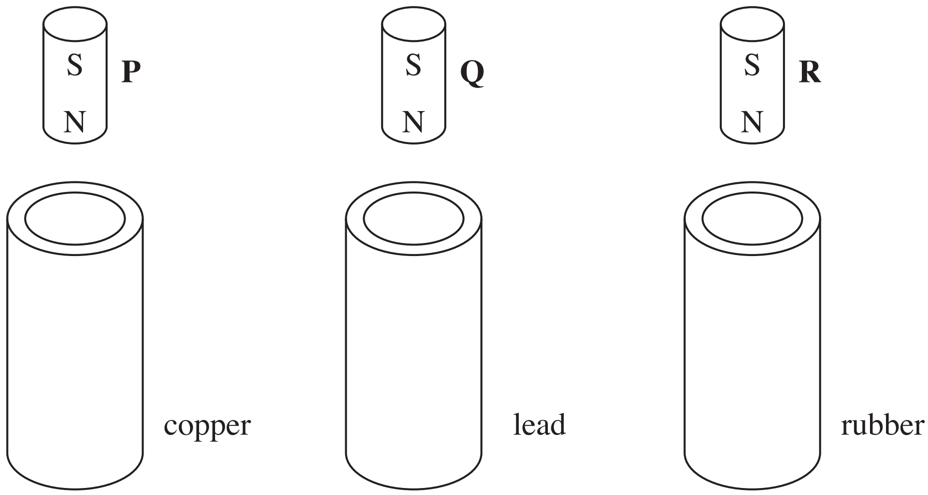
21 A beam of positive ions enters a region of uniform magnetic field, causing the beam to change direction as shown in the diagram.



What is the direction of the magnetic field?

A out of the page and perpendicular to it
B into the page and perpendicular to it
C in the direction indicated by **+y**
D in the direction indicated by **–y**

22 Three vertical tubes, made from copper, lead and rubber respectively, have identical dimensions. Identical, strong, cylindrical magnets **P**, **Q** and **R** are released simultaneously from the same distance above each tube. Because of electromagnetic effects, the magnets emerge from the bottom of the tubes at different times.



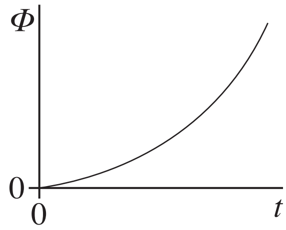
Which line, **A** to **D**, in the table shows the correct order in which they will emerge?

resistivity of copper = $1.7 \times 10^{-8}\,\Omega\text{m}$
resistivity of lead = $22 \times 10^{-8}\,\Omega\text{m}$
resistivity of rubber = $50 \times 10^{13}\,\Omega\text{m}$

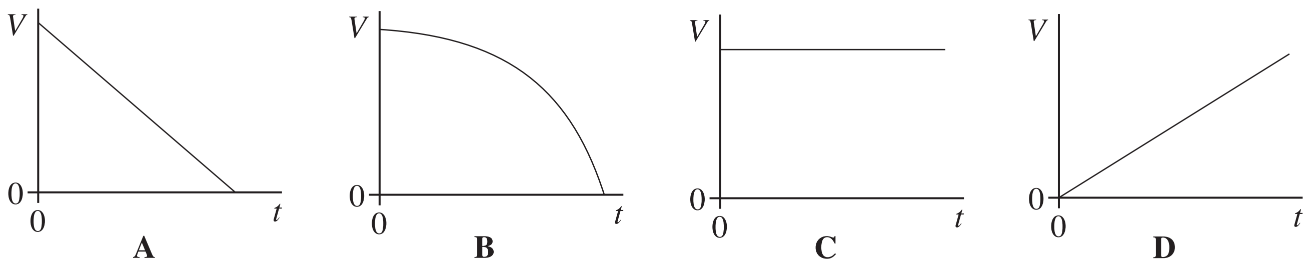
	emerges first	**emerges second**	**emerges third**
A	**P**	**Q**	**R**
B	**R**	**P**	**Q**
C	**P**	**R**	**Q**
D	**R**	**Q**	**P**

Turn over ►

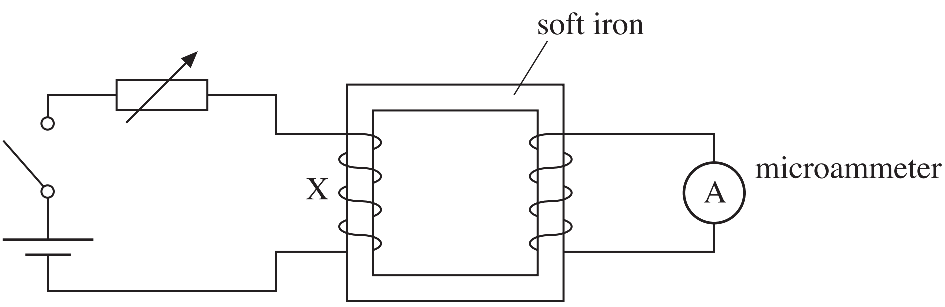
23 The graph shows how the magnetic flux, Φ, passing through a coil changes with time, t.



Which one of the following graphs could show how the magnitude of the emf, V, induced in the coil varies with t?



24 Using the circuit shown, and with the switch closed, a small current was passed through the coil X. The current was slowly increased using the variable resistor. The current reached a maximum value and was then switched off.



The maximum reading on the microammeter occurred when

A the small current flowed at the start.
B the current was being increased.
C the current was being switched off.
D the current in X was zero.

25 When a mobile phone is being recharged, the charger heats up. The efficiency of the transformer in the charger can be as low as 15% when drawing a current of 50 mA from a 230 V mains supply. If the charging current required is 350 mA, what is the approximate output voltage at this efficiency?

A 4.9 V
B 11 V
C 28 V
D 33 V

END OF QUESTIONS

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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 2012

Physics A PHYA4/2

Unit 4 Fields and Further Mechanics
Section B

Monday 11 June 2012 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.
- 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.

Answer **all** questions.

You are advised to spend approximately **one hour** on this section.

1 (a) State, in words, the relationship between the force acting on a body and the momentum of the body.

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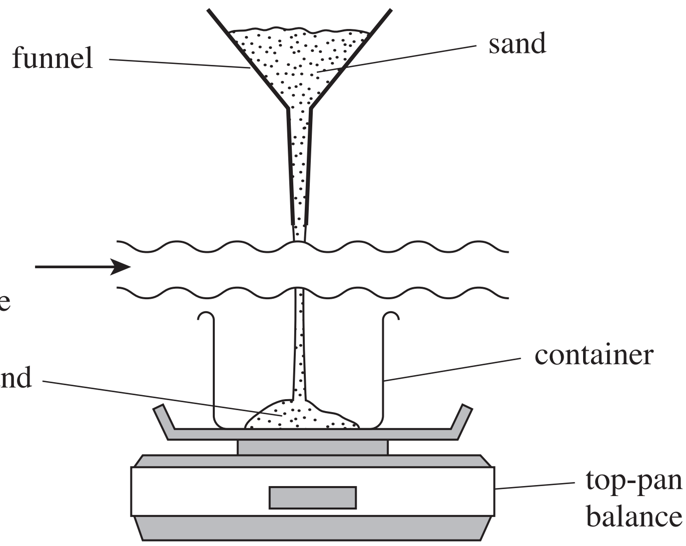
(1 mark)

1 (b) A container rests on a top-pan balance, which measures mass in kg. A funnel above the container holds some sand. The sand falls at a constant rate of $0.300\,\text{kg}\,\text{s}^{-1}$ into the container, having fallen through an average vertical height of 1.60 m. This arrangement is shown in **Figure 1**.

Figure 1



1 (b) (i) Show that the velocity of the sand as it lands in the container is $5.6\,\text{m}\,\text{s}^{-1}$.

(1 mark)

1 (b) (ii) Calculate the magnitude of the momentum of the sand that lands in the container in each second.

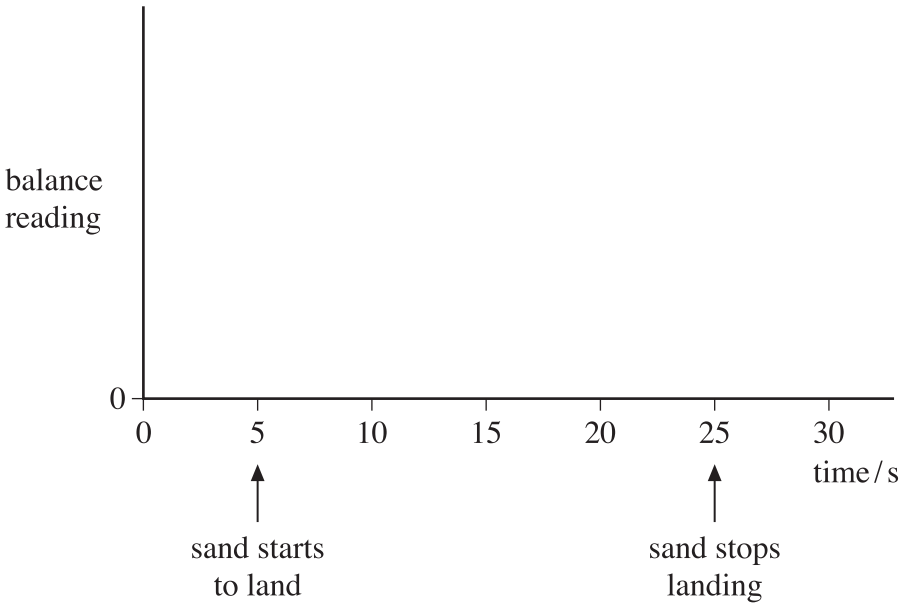
answer = ... N s

(1 mark)

1 (b) (iii) The mass of the container is 0.650 kg. Show that the reading of the balance, 10.0 s after the sand starts landing continuously in the container, will be 3.82 kg. You may assume that the sand comes to rest without rebounding when it lands in the container.

(3 marks)

1 (c) It takes 20.0 s for all of the sand to fall into the container.
On the axes below, sketch a graph to show how the reading of the balance will change over a 30.0 s period, where t = 5.0 s is the time at which the sand starts to land in the container. No further calculations are required and values need not be shown on the vertical axis of the graph.

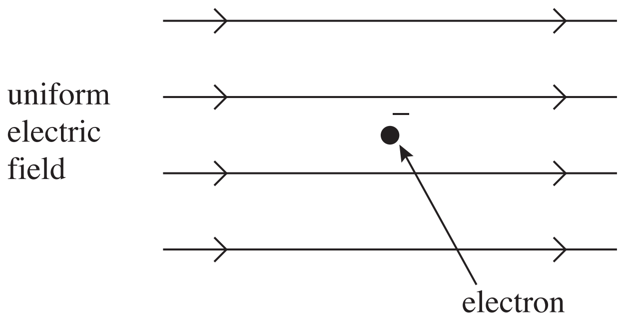


(3 marks)

9

2 (a) **Figure 2** shows an electron at a point in a uniform electric field at an instant when it is stationary.

Figure 2



2 (a) (i) Draw an arrow on **Figure 2** to show the direction of the electrostatic force that acts on the stationary electron.

(1 mark)

2 (a) (ii) State and explain what, if anything, will happen to the magnitude of the electrostatic force acting on the electron as it starts to move in this field.

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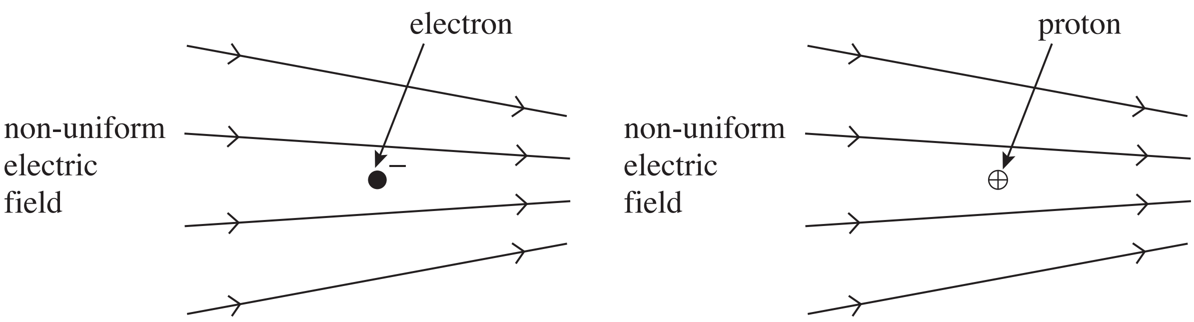
(2 marks)

2 (b) **Figure 3a** shows a stationary electron in a non-uniform electric field. **Figure 3b** shows a stationary proton, placed in exactly the same position in the same electric field as the electron in **Figure 3a**.

Figure 3a **Figure 3b**



2 (b) (i) State and explain how the electrostatic force on the proton in **Figure 3b** compares with that on the electron in **Figure 3a**.

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(2 marks)

2 (b) (ii) Each of the particles starts to move from the positions shown in **Figure 3a** and **Figure 3b**. State and explain how the magnitude of the **initial** acceleration of the proton compares with that of the electron.

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(2 marks)

2 (b) (iii) Describe and explain what will happen to the acceleration of each of these particles as they continue to move in the electric field.

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(2 marks)

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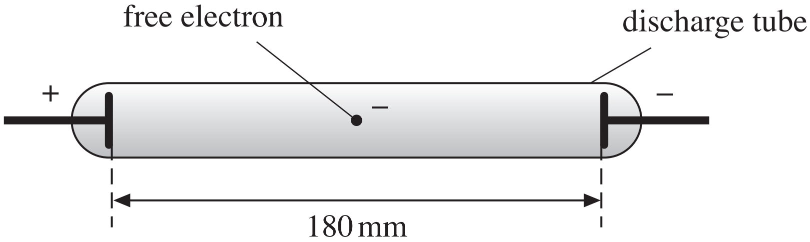
2 (c) The line spectrum of neon gas contains a prominent red line of wavelength 650 nm.

2 (c) (i) Show that the energy required to excite neon atoms so that they emit light of this wavelength is about 2 eV.

(3 marks)

2 (c) (ii) An illuminated shop sign includes a neon discharge tube, as shown in **Figure 4**. A pd of 4500 V is applied across the electrodes, which are 180 mm apart.

Figure 4



Assuming that the electric field inside the tube is uniform, calculate the minimum distance that a free electron would have to move from rest in order to excite the red spectral line in part (c).

answer = ... m

(3 marks)

15

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3 The Large Hadron Collider (LHC) uses magnetic fields to confine fast-moving charged particles travelling repeatedly around a circular path. The LHC is installed in an underground circular tunnel of circumference 27 km.

3 (a) In the presence of a suitably directed uniform magnetic field, charged particles move at constant speed in a circular path of constant radius. By reference to the force acting on the particles, explain how this is achieved and why it happens.

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(4 marks)

3 (b) (i) The charged particles travelling around the LHC may be protons. Calculate the centripetal force acting on a proton when travelling in a circular path of circumference 27 km at one-tenth of the speed of light. Ignore relativistic effects.

answer = ... N

(3 marks)

Turn over ▶

3 (b) (ii) Calculate the flux density of the uniform magnetic field that would be required to produce this force. State an appropriate unit.

answer = ... unit ....

(3 marks)

3 (c) The speed of the protons gradually increases as their energy is increased by the LHC. State and explain how the magnetic field in the LHC must change as the speed of the protons is increased.

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(2 marks)

12

4 (a) Define the gravitational potential at a point in a gravitational field.

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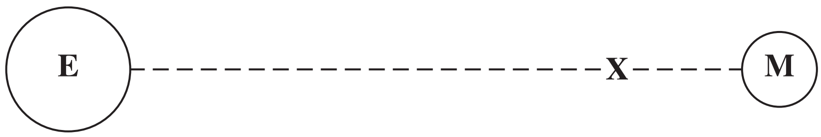
(2 marks)

4 (b) **Figure 5**, which is not drawn to scale, shows the region between the Earth (**E**) and the Moon (**M**).

Figure 5



4 (b) (i) The gravitational potential at the Earth's surface is $-62.6\,\text{MJ kg}^{-1}$. Point **X** shown in **Figure 5** is on the line of centres between the Earth and the Moon At **X** the resultant gravitational field is zero, and the gravitational potential is $-1.3\,\text{MJ kg}^{-1}$.

Calculate the minimum amount of energy that would be required to move a Moon probe of mass 1.2×10^4 kg from the surface of the Earth to point **X**. Express your answer to an appropriate number of significant figures.

answer = ... J

(3 marks)

4 (b) (ii) Explain why, once the probe is beyond **X**, no further energy would have to be supplied in order for it to reach the surface of the Moon.

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(1 mark)

Turn over ▶

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4 (b) (iii) In the vicinity of the Earth's orbit the gravitational potential due to the Sun's mass is $-885\,\text{MJ}\,\text{kg}^{-1}$. With reference to the variation in gravitational potential with distance, explain why the gravitational potential due to the Sun's mass need not be considered when carrying out the calculation in part (b)(i).

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(2 marks)

4 (c) The amount of energy required to move a manned spacecraft from the Earth to the Moon is much greater than that required to return it to the Earth. By reference to the forces involved, to gravitational field strength and gravitational potential, and to the point **X**, explain why this is so.

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

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(6 marks)

14

END OF QUESTIONS

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