Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

General Certificate of Education
Advanced Level Examination
June 2013

Physics A PHYA4/1

Unit 4 Fields and Further Mechanics
Section A

Thursday 13 June 2013 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 Which one of the following is a possible unit of impulse?

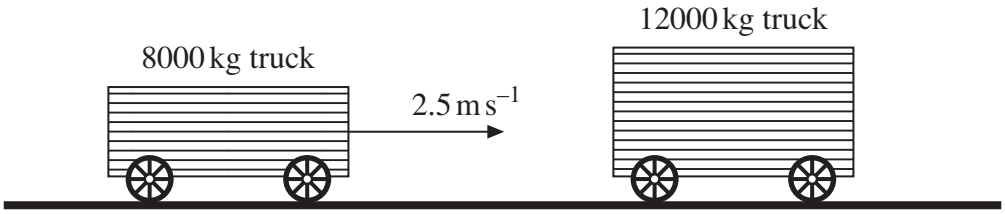
A $N\,s^{-1}$

B $kg\,m\,s^{-1}$

C $kg\,m\,s^{-2}$

D $s\,N^{-1}$

2 A railway truck of mass 8000 kg travels along a level track at a velocity of $2.5\,m\,s^{-1}$ and collides with a stationary truck of mass 12000 kg. The two trucks move together at the same velocity after the collision.



What is the change in momentum of the 8000 kg truck due to the impact?

A 8000 N s

B 12000 N s

C 20000 N s

D 25000 N s

3 A gas molecule of mass m moving at velocity u collides at right angles with the side of a container and rebounds elastically. Which one of the following statements concerning the motion of the molecule is **incorrect**?

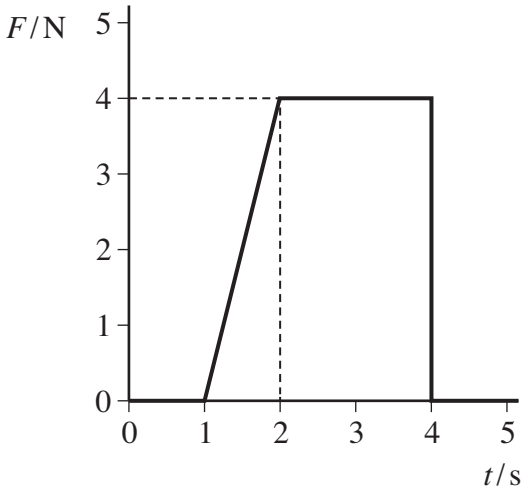
A The magnitude of the change in momentum of the molecule is zero.

B The magnitude of the change in momentum of the molecule is $2mu$.

C The force exerted by the molecule on the side of the container is equal to the force exerted by the container on the molecule.

D The change in kinetic energy of the molecule is zero.

4 The graph shows how the resultant force, F, acting on a body varies with time, t.



What is the change in momentum of the body over the 5 s period?

A 2 N s

B 8 N s

C 10 N s

D 12 N s

5 The wheel of the London Eye has a diameter of 130 m and rotates at a steady speed, completing one rotation every 30 minutes. What is the centripetal acceleration of a person in a capsule at the rim of the wheel?

A $1.2 \times 10^{-4}\,\text{m s}^{-2}$

B $2.5 \times 10^{-4}\,\text{m s}^{-2}$

C $3.9 \times 10^{-4}\,\text{m s}^{-2}$

D $7.9 \times 10^{-4}\,\text{m s}^{-2}$

6 A small body of mass m rests on a horizontal turntable at a distance r from the centre. If the maximum frictional force between the body and the turntable is $\frac{mg}{2}$, what is the angular speed at which the body starts to slip?

A $\sqrt{\frac{gr}{2}}$

B $\frac{g}{r}$

C $\sqrt{\frac{g}{2r}}$

D $\frac{1}{2}\sqrt{\frac{g}{r}}$

7 A body of mass 0.50 kg, fixed to one end of a string, is rotated in a vertical circle of radius 1.5 m at an angular speed of 5.0 rad s^{-1}. What is the maximum tension in the string?

A 5.0 N

B 9.0 N

C 14 N

D 24 N

8 A particle of mass m oscillates in a straight line with simple harmonic motion of constant amplitude. The total energy of the particle is E. What is the total energy of another particle of mass $2m$, oscillating with simple harmonic motion of the same amplitude but double the frequency?

A E

B $2E$

C $4E$

D $8E$

9 When a mass suspended on a spring is displaced, the system oscillates with simple harmonic motion. Which one of the following statements regarding the energy of the system is **incorrect**?

A The potential energy has a minimum value when the spring is fully compressed or fully extended.

B The kinetic energy has a maximum value at the equilibrium position.

C The sum of the kinetic and potential energies at any time is constant.

D The potential energy has a maximum value when the mass is at rest.

10 When a mass M attached to a spring X, as shown in **Figure 1**, is displaced downwards and released it oscillates with time period T. An identical spring is connected in series and the same mass M is attached, as shown in **Figure 2**.

What is the new time period?

Figure 1

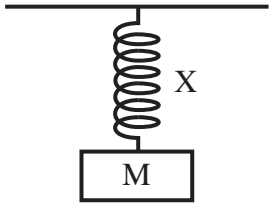
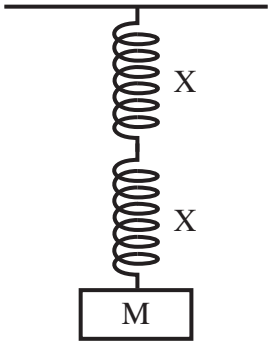


Figure 2



A $\frac{T}{2}$

B $\frac{T}{\sqrt{2}}$

C $\sqrt{2}T$

D $2T$

11 When a space shuttle is in a low orbit around the Earth it experiences gravitational forces F_E due to the Earth, F_M due to the Moon and F_S due to the Sun. Which one of the following correctly shows how the magnitudes of these forces are related to each other?

mass of Sun = 1.99×10^{30} kg
mass of Moon = 7.35×10^{22} kg
mean distance from Earth to Sun = 1.50×10^{11} m
mean distance from Earth to Moon = 3.84×10^{8} m

A $F_E > F_S > F_M$

B $F_S > F_E > F_M$

C $F_E > F_M > F_S$

D $F_M > F_E > F_S$

12 The gravitational field strengths at the surfaces of the Earth and the Moon are $9.8\,N\,kg^{-1}$ and $1.7\,N\,kg^{-1}$ respectively. If the mass of the Earth is $81 \times$ the mass of the Moon, what is the ratio of the radius of the Earth to the radius of the Moon?

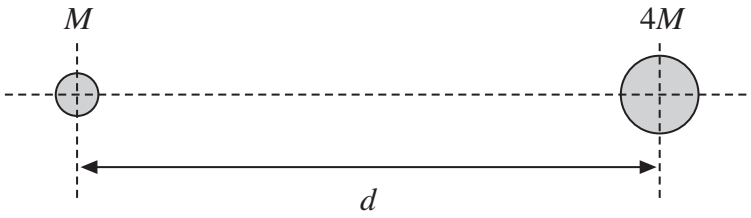
A 3.7

B 5.8

C 14

D 22

13 Two stars of mass M and $4M$ are at a distance d between their centres.



The resultant gravitational field strength is zero along the line between their centres at a distance y from the centre of the star of mass M.

What is the value of the ratio $\frac{y}{d}$?

A $\frac{1}{2}$

B $\frac{1}{3}$

C $\frac{2}{3}$

D $\frac{3}{4}$

14 Mars has a diameter approximately 0.5 that of the Earth, and a mass of 0.1 that of the Earth.
The gravitational potential at the Earth's surface is $-63\,\text{MJ kg}^{-1}$.
What is the approximate value of the gravitational potential at the surface of Mars?

A $-13\,\text{MJ kg}^{-1}$

B $-25\,\text{MJ kg}^{-1}$

C $-95\,\text{MJ kg}^{-1}$

D $-320\,\text{MJ kg}^{-1}$

15 Two satellites P and Q, of equal mass, orbit the Earth at radii R and $2R$ respectively.
Which one of the following statements is correct?

A P has less kinetic energy and more potential energy than Q.

B P has less kinetic energy and less potential energy than Q.

C P has more kinetic energy and less potential energy than Q.

D P has more kinetic energy and more potential energy than Q.

16 Two horizontal parallel plate conductors are separated by a distance of 5.0 mm in air. The lower plate is earthed and the potential of the upper plate is +50 V.

Which line, **A** to **D**, in the table gives correctly the electric field strength, E, and the potential, V, at a point midway between the plates?

	electric field strength E / V m^{-1}	**potential V / V**
A	1.0×10^4 upwards	25
B	1.0×10^4 downwards	25
C	1.0×10^4 upwards	50
D	1.0×10^4 downwards	50

17 Two identical positive point charges, P and Q, separated by a distance r, repel each other with a force F. If r is decreased so that the electrical potential energy of Q is doubled, what is the force of repulsion?

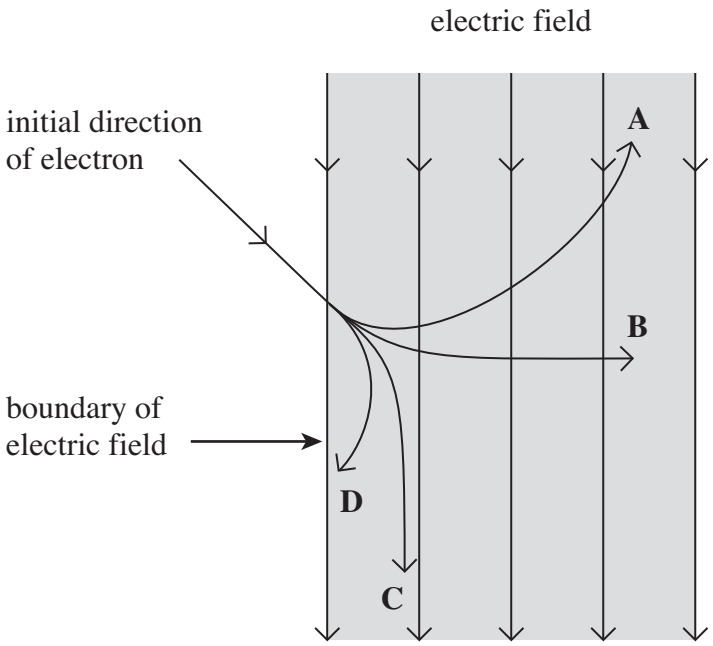
A $0.5F$

B F

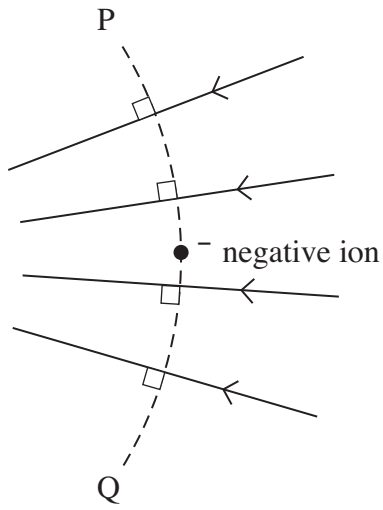
C $2F$

D $4F$

18 Which path, **A** to **D**, shows how an electron moves in the uniform electric field represented in the diagram?



19 The diagram shows a negative ion at a point in an electric field, which is represented by the arrowed field lines.



Which one of the following statements correctly describes what happens when the ion is displaced?

When the negative ion is displaced

A to the left the magnitude of the electric force on it decreases.

B to the right its potential energy increases.

C along the line PQ towards Q its potential energy decreases.

D along the line PQ towards P the magnitude of the electric force on it is unchanged.

20 A nuclear fusion device is required to deliver at least 1 MJ of energy using capacitors. If the largest workable potential difference is 10 kV, what is the minimum capacitance of the capacitors that should be used?

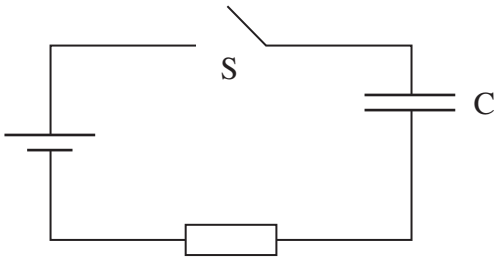
A 0.01 F

B 0.02 F

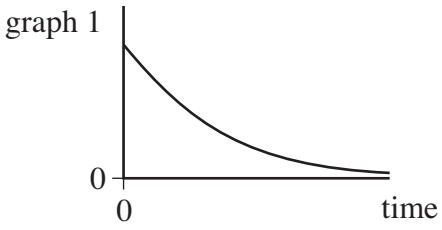
C 2 F

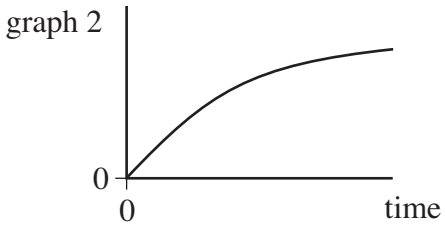
D 100 F

21 In the circuit shown the capacitor C charges when switch S is closed.



Which line, **A** to **D**, in the table gives a correct pair of graphs showing how the charge on the capacitor and the current in the circuit change with time after S is closed?





	charge	**current**
A	graph 1	graph 1
B	graph 1	graph 2
C	graph 2	graph 2
D	graph 2	graph 1

Turn over for the next question

22 The voltage across a capacitor falls from 10 V to 5 V in 48 ms as it discharges through a resistor.
What is the time constant of the circuit?

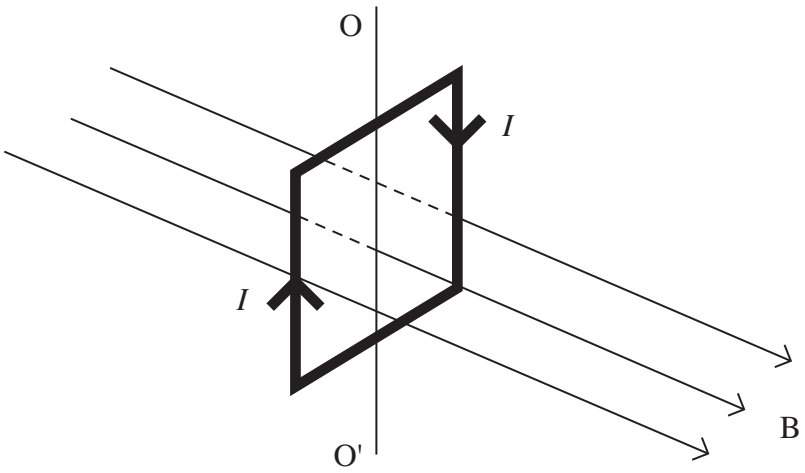
A 24 ms

B 33 ms

C 69 ms

D 96 ms

23 The diagram shows a vertical square coil whose plane is at right angles to a horizontal uniform magnetic field B. A current, *I*, is passed through the coil, which is free to rotate about a vertical axis OO'.



Which one of the following statements is correct?

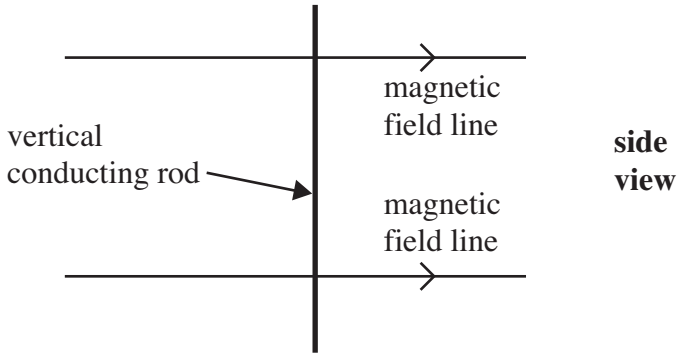
A The forces on the two vertical sides of the coil are equal and opposite.

B A couple acts on the coil.

C No forces act on the horizontal sides of the coil.

D If the coil is turned through a small angle about OO' and released, it will remain in position.

24 A vertical conducting rod of length l is moved at a constant velocity v through a uniform horizontal magnetic field of flux density B.



Which line, **A** to **D**, in the table gives a correct expression for the induced emf for the stated direction of the motion of the rod?

	direction of motion	**induced emf**
A	vertical	$\frac{B}{lv}$
B	horizontal at right angles to the field	Blv
C	vertical	Blv
D	horizontal at right angles to the field	$\frac{B}{lv}$

25 A transformer, which is not perfectly efficient, is connected to a 230 V rms mains supply and is used to operate a 12 V rms, 60 W lamp at normal brightness. The secondary coil of the transformer has 24 turns.

Which line, **A** to **D**, in the table is correct?

	number of turns on primary coil	**rms current in primary coil**
A	92	less than 0.26 A
B	92	more than 0.26 A
C	460	less than 0.26 A
D	460	more than 0.26 A

END OF QUESTIONS

There are no questions printed on this page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
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TOTAL	

General Certificate of Education
Advanced Level Examination
June 2013

Physics A PHYA4/2

Unit 4 Fields and Further Mechanics
Section B

Thursday 13 June 2013 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.

Answer **all** questions in the spaces provided.
You are advised to spend approximately **one hour** on this section.

1 (a) A simple pendulum is given a small displacement from its equilibrium position and performs *simple harmonic motion*.

State what is meant by simple harmonic motion.

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(2 marks)

1 (b) (i) Calculate the frequency of the oscillations of a simple pendulum of length 984 mm. Give your answer to an appropriate number of significant figures.

frequency ..... Hz

(3 marks)

1 (b) (ii) Calculate the acceleration of the bob of the simple pendulum when the displacement from the equilibrium position is 42 mm.

acceleration ..... $m\,s^{-2}$

(2 marks)

1 (c) A simple pendulum of time period 1.90 s is set up alongside another pendulum of time period 2.00 s. The pendulums are displaced in the same direction and released at the same time.

Calculate the time interval until they next move in phase. Explain how you arrive at your answer.

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time interval ..... s

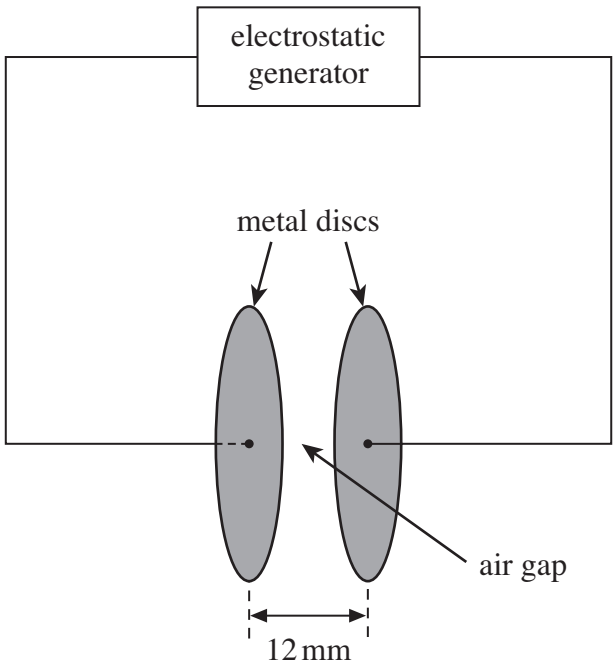
(3 marks)

10

Turn over for the next question

2 **Figure 1** shows an arrangement to demonstrate sparks passing across an air gap between two parallel metal discs. Sparks occur when the electric field in the gap becomes large enough to equal the breakdown field strength of the air. The discs form a capacitor, which is charged at a constant rate by an electrostatic generator until the potential difference (pd) across the discs is large enough for a spark to pass. Sparks are then produced at regular time intervals whilst the generator is switched on.

Figure 1



2 (a) The electrostatic generator charges the discs at a constant rate of 3.2×10^{-8} A on a day when the minimum breakdown field strength of the air is 2.5×10^{6} V m^{-1}. The discs have a capacitance of 3.7×10^{-12} F.

2 (a) (i) The air gap is 12 mm wide. Calculate the minimum pd required across the discs for a spark to occur. Assume that the electric field in the air gap is uniform.

pd V

(1 mark)

2 (a) (ii) Calculate the time taken, from when the electrostatic generator is first switched on, for the pd across the discs to reach the value calculated in part (a)(i).

time ..... s

(2 marks)

2 (b) The discs are replaced by ones of larger area placed at the same separation, to give a larger capacitance.

State and explain what effect this increased capacitance will have on:

2 (b) (i) the time between consecutive discharges,

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(2 marks)

2 (b) (ii) the brightness of each spark.

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(2 marks)

7

3 (a) (i) State **two** situations in which a charged particle will experience no magnetic force when placed in a magnetic field.

first situation .....

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second situation .....

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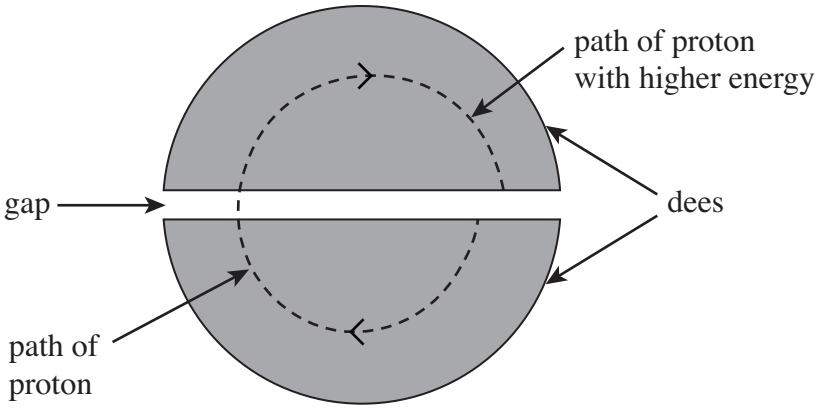
(2 marks)

3 (a) (ii) A charged particle moves in a circular path when travelling perpendicular to a uniform magnetic field. By considering the force acting on the charged particle, show that the radius of the path is proportional to the momentum of the particle.

(2 marks)

3 (b) In a cyclotron designed to produce high energy protons, the protons pass repeatedly between two hollow D-shaped containers called 'dees'. The protons are acted on by a uniform magnetic field over the whole area of the dees. Each proton therefore moves in a semi-circular path at constant speed when inside a dee. Every time a proton crosses the gap between the dees it is accelerated by an alternating electric field applied between the dees. **Figure 2** shows a plan view of this arrangement.

Figure 2



3 (b) (i) State the direction in which the magnetic field should be applied in order for the protons to travel along the semicircular paths inside each of the dees as shown in **Figure 2**.

.....

(1 mark)

3 (b) (ii) In a particular cyclotron the flux density of the uniform magnetic field is 0.48 T. Calculate the speed of a proton when the radius of its path inside the dee is 190 mm.

speed ..... $m\,s^{-1}$

(2 marks)

3 (b) (iii) Calculate the time taken for this proton to travel at constant speed in a semicircular path of radius 190 mm inside the dee.

time ..... s

(2 marks)

3 (b) (iv) As the protons gain energy, the radius of the path they follow increases steadily, as shown in **Figure 2**. Show that your answer to part (b)(iii) does not depend on the radius of the proton's path.

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(2 marks)

Turn over ▶

3 (c) The protons leave the cyclotron when the radius of their path is equal to the outer radius of the dees. Calculate the maximum kinetic energy, in MeV, of the protons accelerated by the cyclotron if the outer radius of the dees is 470 mm.

maximum kinetic energy ..... MeV
(3 marks)

14

4 Gravitational fields and electric fields have many features in common but also have several differences. For both radial and uniform gravitational and electric fields, compare and contrast their common features and their differences.

In your answer you should consider:

- the force acting between particles or charges
- gravitational field strength and electric field strength
- gravitational potential and electric potential.

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

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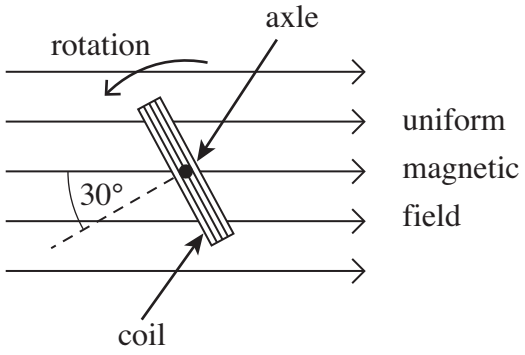
(6 marks)

6

5 A rectangular coil is rotating anticlockwise at constant angular speed with its axle at right angles to a uniform magnetic field. **Figure 3** shows an end-on view of the coil at a particular instant.

Figure 3



5 (a) At the instant shown in **Figure 3**, the angle between the normal to the plane of the coil and the direction of the magnetic field is 30°.

5 (a) (i) State the minimum angle, in degrees, through which the coil must rotate from its position in **Figure 3** for the emf to reach its maximum value.

angle ..... degrees
(1 mark)

5 (a) (ii) Calculate the minimum angle, in radians, through which the coil must rotate from its position in **Figure 3** for the flux linkage to reach its maximum value.

angle ..... radians
(2 marks)

5 (b) **Figure 4** shows how, starting in a different position, the flux linkage through the coil varies with time.

5 (b) (i) What physical quantity is represented by the gradient of the graph shown in **Figure 4**?

.....
(1 mark)

5 (b) (ii) Calculate the number of revolutions per minute made by the coil.

revolutions per minute .....
(2 marks)

Figure 4

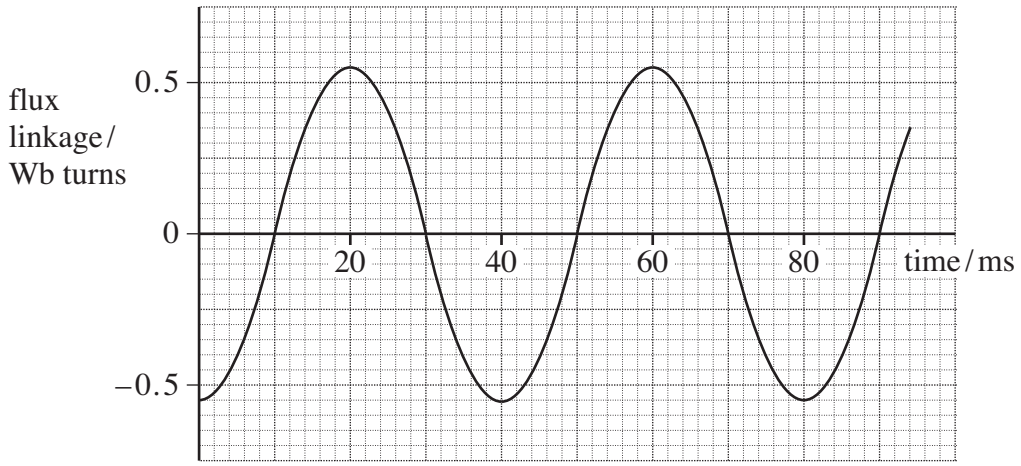
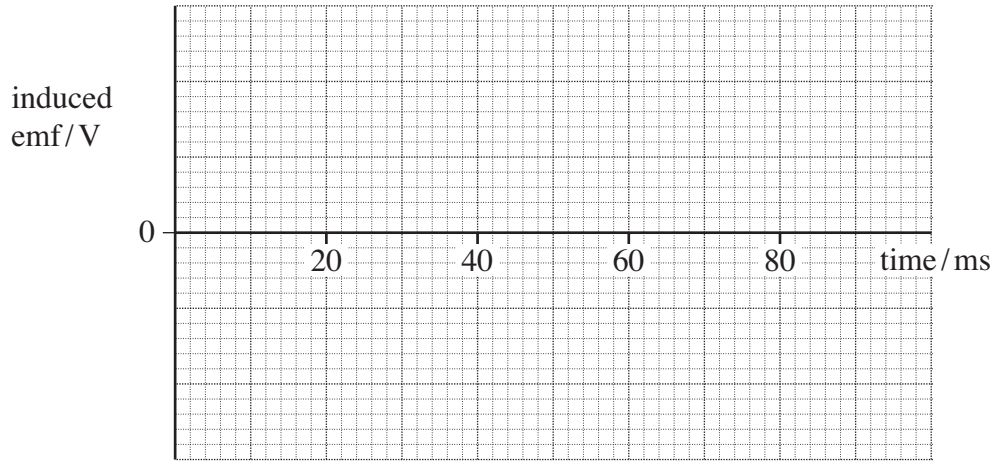


Figure 5



5 (b) (iii) Calculate the peak value of the emf generated.

peak emf V

(3 marks)

5 (c) Sketch a graph on the axes shown in **Figure 5** above to show how the induced emf varies with time over the time interval shown in **Figure 4**.

(2 marks)

5 (d) The coil has 550 turns and a cross-sectional area of $4.0 \times 10^{-3}\,m^2$.

Calculate the flux density of the uniform magnetic field.

flux density ..... T

(2 marks)

13

END OF QUESTIONS