OXFORD

INTERNATIONAL AQA EXAMINATIONS

Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname _____

Forename(s) _____

Candidate signature _____

INTERNATIONAL A-LEVEL

PHYSICS

Unit 3 Fields and their consequences

Wednesday 13 June 2018 07:00 GMT Time allowed: 2 hours

Materials

For this paper you must have:
- A Data and Formulae Booklet as a loose insert
- a ruler with millimetre measurements
- a scientific calculator, which you are expected to use where appropriate.

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 spaces provided. Do not write outside the box around each page or on blank pages.
- All working must be shown.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 80.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
6	
7–36	
TOTAL	

Do not write outside the box

Section A

Answer **all** questions in this section.

0 1 A child is sitting on a swing. The swing is pulled back and released from rest at time $t = 0$
The child and swing oscillate with simple harmonic motion.

0 1 . 1 Outline what is meant by simple harmonic motion.

[2 marks]

0 1 . 2 The child and swing behave as a simple pendulum of length $2.25\ \text{m}$.

Show that the period of oscillation of the swing is approximately $3\ \text{s}$.

[2 marks]

Do not write outside the box

0 1 . 3 The amplitude of the motion is $1.20\ \text{m}$.
The combined mass of the child and the swing is $18\ \text{kg}$.

Calculate the change in kinetic energy of the child and swing as the system moves from the point of maximum displacement to the equilibrium position.

[3 marks]

change in kinetic energy = _____ J

Question 1 continues on the next page

Do not write outside the box

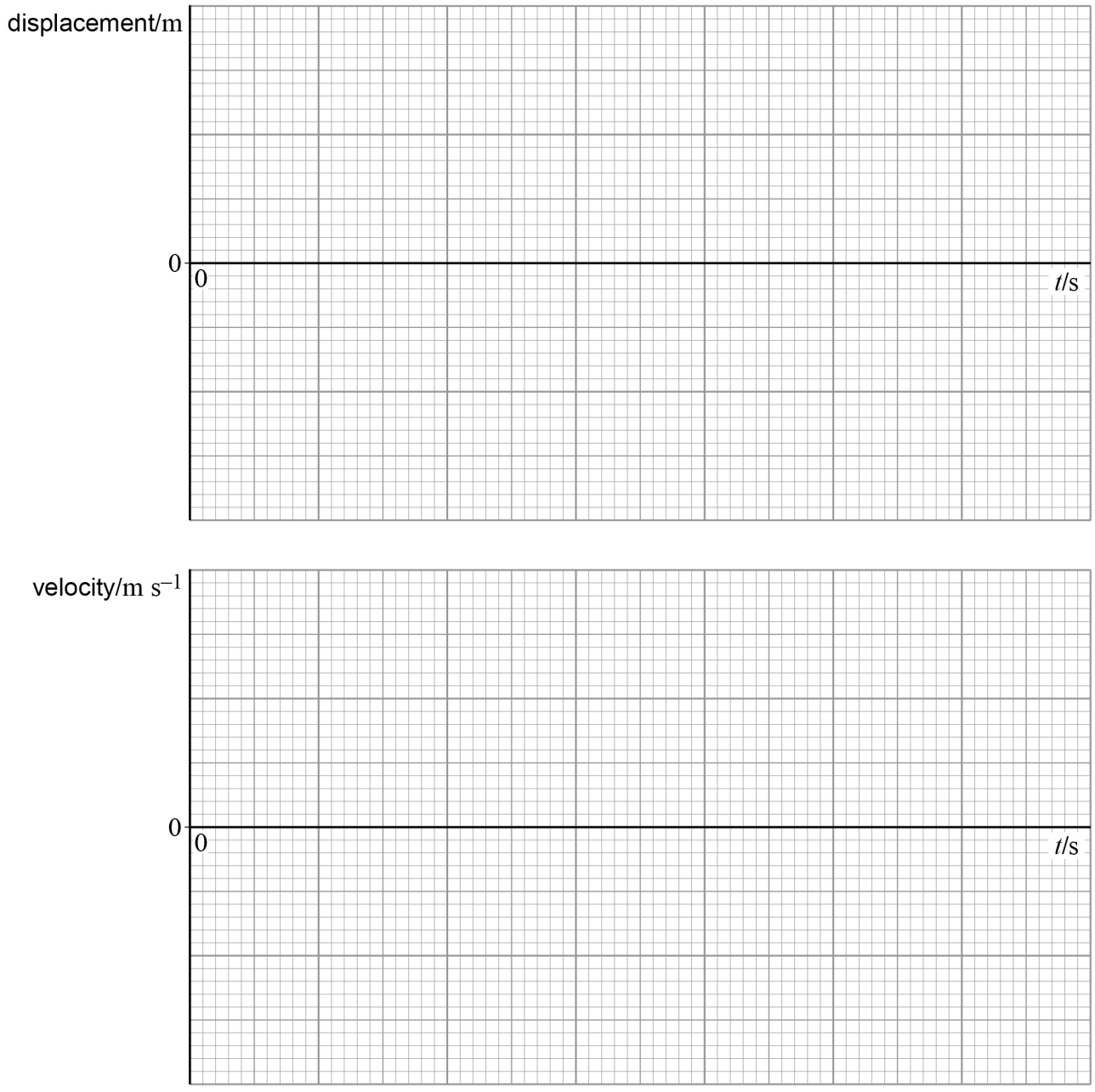
0 1 . 4 Sketch, on **Figure 1**, graphs to show the variation of displacement with time and the variation of velocity with time for two complete oscillations of the swing.

You should:

- start each graph from $t = 0$
- add suitable scales to all axes
- have the same scale on the t axis for both graphs.

[4 marks]

Figure 1



11

Do not write outside the box

Turn over for the next question

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

Do not write outside the box

0 2 A space mission is planned to remove a small boulder of mass 8.2×10^3 kg from the surface of an asteroid.

0 2 . 1 The gravitational field strength is 1.77×10^{-4} N kg^{-1} at the surface of the asteroid.

Calculate the weight of the boulder at the surface of the asteroid.

[1 mark]

weight = _____ N

0 2 . 2 Explain why gravitational potential is always a negative quantity.

[2 marks]

_____

_____

_____

_____

0 2 . 3 The gravitational potential at the surface of the asteroid, due to the asteroid's gravitational field, is -3.99×10^{-2} J kg^{-1}
A spacecraft of mass 1.8×10^4 kg removes the boulder to a position where the gravitational potential is negligible.

Calculate the work done against the asteroid's gravitational field.

[1 mark]

work done = _____ J

Do not write outside the box

0 2 . 4 The boulder will be placed into a circular orbit around the Moon.

Show that the period T of the circular orbit of the boulder around the Moon is given by

$$T = \sqrt{\frac{4\pi^2 r^3}{GM}}$$

where r = the radius of the orbit
and M = mass of the Moon.

[3 marks]

0 2 . 5 The orbital period of the orbit around the Moon is $24\ \text{h}$.
The mass of the Moon is $7.35 \times 10^{22}\ \text{kg}$.

Calculate the radius of the orbit.

[2 marks]

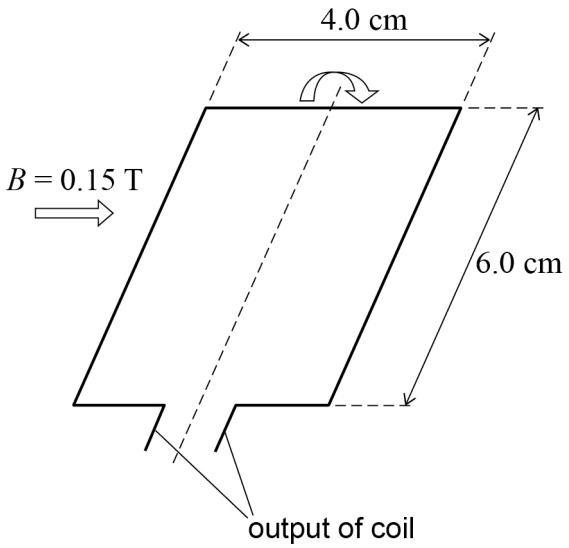
radius of orbit = _____ m

9

Do not write outside the box

0 3 The rectangular coil shown in **Figure 2** rotates at a constant frequency of 40 Hz about an axis that is perpendicular to a uniform magnetic field of flux density 0.15 T.
The coil has a length of 6.0 cm and width 4.0 cm and has 25 turns.

Figure 2



0 3 . 1 Calculate the peak emf induced in the coil.

[3 marks]

peak emf = _____ V

0 3 . 2 Calculate the root mean square value of the emf induced in the coil.

[1 mark]

root mean square emf = _____ V

Do not write outside the box

0 3 . 3 A $6.8\ \Omega$ resistor is connected across the output of the coil. Assume that the coil has zero resistance.

Calculate the mean power dissipated in the resistor.

[2 marks]

mean power = _____ W

0 3 . 4 To increase the mean power dissipated in the resistor, it is suggested that either the magnetic flux density or the angular speed of the coil could be doubled.

Deduce the effects of each of these possible changes on the output of the coil.

[3 marks]

9

Do not write outside the box

0 4 Thallium–208 is a radioactive nuclide with a half-life of 183 s.
It decays to a stable nuclide, lead–208

At time $t = 0$, a pure sample of thallium–208 contains 6.5×10^{20} nuclei.

0 4 . 1 Define decay constant.

[1 mark]

0 4 . 2 Calculate the number of nuclei of thallium–208 nuclei that decay between $t = 0$ and $t = 400$ s.

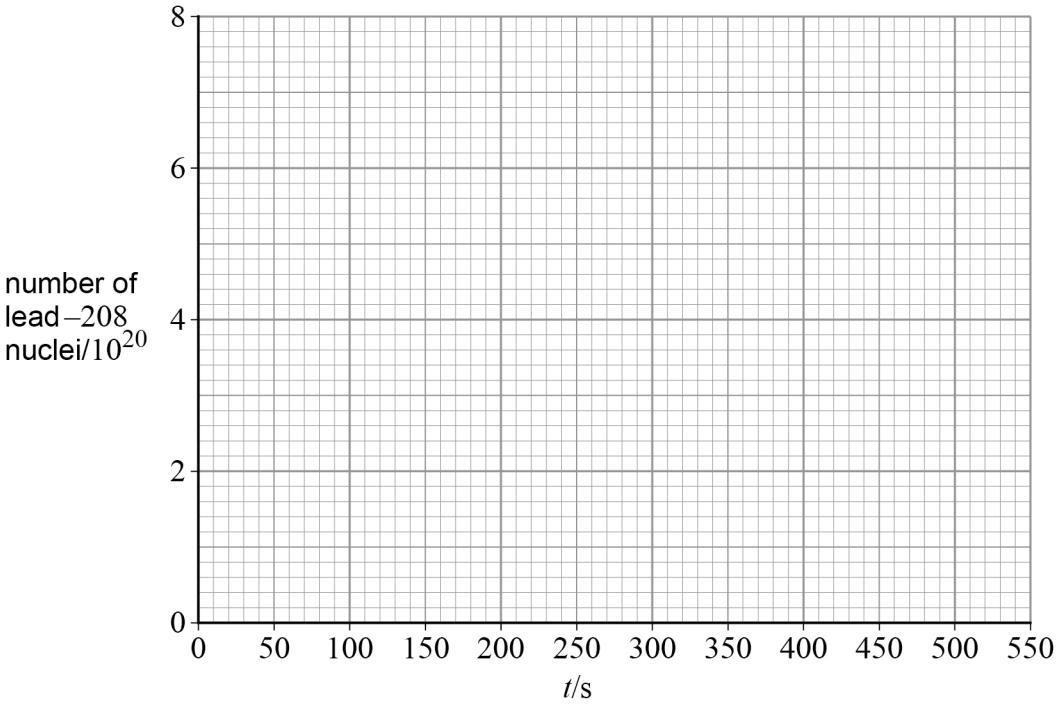
[3 marks]

number of nuclei = _____

Do not write outside the box

0 4 . 3 Sketch on the axes below a graph of the variation with time of the number of lead–208 nuclei in the sample.

[2 marks]



6

Turn over for the next question

Do not write outside the box

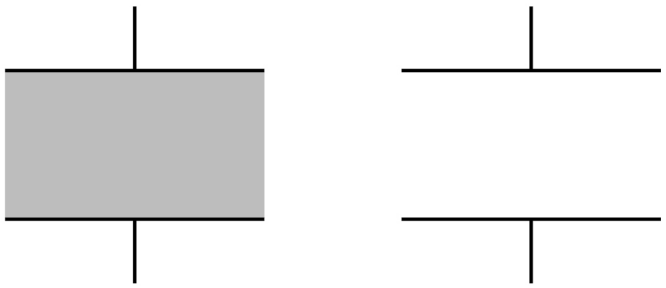
0 5 . 1 A capacitor has a capacitance of $80\ \mu F$.

State what is meant by a capacitance of $80\ \mu F$.

[1 mark]

0 5 . 2 **Figure 3** shows a parallel plate capacitor with and without a dielectric between the plates.

Figure 3



capacitor with dielectric capacitor without dielectric

Explain how the presence of a dielectric between the plates increases the capacitance of the capacitor.
You may add to **Figure 3** to assist your explanation.

[3 marks]

Do not write outside the box

0 5 . 3 An $80\ \mu F$ capacitor is charged so that the potential difference across it is $5.0\ V$. The capacitor is then partially discharged, losing $120\ \mu C$ of charge.

Calculate the percentage reduction in the energy stored in the capacitor due to the partial discharge.

[4 marks]

percentage reduction in energy = _____

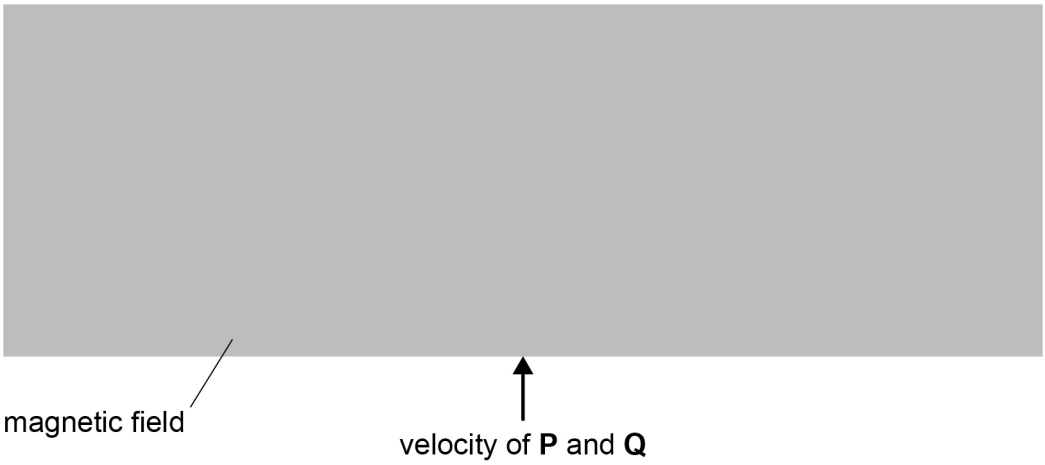
8

Turn over for the next question

Do not write outside the box

0 6 **Figure 4** shows where two equally charged oxygen ions **P** and **Q** enter a uniform magnetic field at $90°$ to the field. The ions each have a velocity of 4.1×10^6 m s^{-1}

Figure 4



charge on **P** and **Q**	=	$+3.2 \times 10^{-19}$ C
magnetic flux density	=	0.93 T
direction of magnetic field	=	out of page
mass of **P**	=	2.66×10^{-26} kg
mass of **Q**	=	2.83×10^{-26} kg

0 6 . 1 Sketch and label the paths of **P** and **Q** on **Figure 4**.

[2 marks]

0 6 . 2 Calculate the difference between the diameters of the paths followed by **P** and **Q** while in the magnetic field.
Ignore any forces acting between the ions.

[4 marks]

difference = _____ m

Do not write outside the box

0 6 . 3 The ions are subject to a magnetic force when they are in the field.

Explain why their speed does not change.

[1 mark]

7

END OF SECTION A

Do not write outside the box

Section B

Each of Questions **07** to **36** is followed by four responses, **A**, **B**, **C** and **D**.

For each question select the best response.

Only **one** answer per question is allowed.
For each question, completely fill in the circle alongside the appropriate answer.

CORRECT METHOD  WRONG METHODS 

If you want to change your answer you must cross out your original answer as shown. 

If you wish to return to an answer previously crossed out, ring the answer you now wish to select as shown. 

You may do your working in the blank space around each question but this will not be marked.
Do **not** use additional sheets for this working.

0 7 A mass on the end of a spring oscillates with simple harmonic motion with a frequency of 2.7 Hz.
The distance between the top and the bottom of the oscillation is 12 cm.

What is the maximum speed of the mass?

[1 mark]

A $0.16\ \text{m s}^{-1}$ ⬭

B $0.32\ \text{m s}^{-1}$ ⬭

C $1.0\ \text{m s}^{-1}$ ⬭

D $2.0\ \text{m s}^{-1}$ ⬭

Do not write outside the box

0 8 Centripetal acceleration is directed

[1 mark]

A along a tangent and opposite to the direction of the motion. ⬭

B along a tangent and in the direction of the motion. ⬭

C towards the centre of circular motion. ⬭

D away from the centre of circular motion. ⬭

0 9 A body of mass m oscillates with simple harmonic motion on a spring of spring constant k. At one instant in the oscillation, the mass is a distance y above the equilibrium position.

Which row gives the magnitude and direction of the acceleration of the mass?

[1 mark]

	Magnitude of the acceleration	**Direction of the acceleration**	
A	$\frac{ky}{m}$	Upwards	⬭
B	$\frac{ky}{m}$	Downwards	⬭
C	$\frac{mg}{ky}$	Upwards	⬭
D	$\frac{mg}{ky}$	Downwards	⬭

Turn over for the next question

Do not write outside the box

1 0 What is the order of magnitude of

$$\frac{\text{gravitational force between proton and electron}}{\text{electrostatic force between proton and electron}}$$

for the proton and the electron in a hydrogen atom?

[1 mark]

A 10^{-40} ⬭

B 10^{-20} ⬭

C 10^{0} ⬭

D 10^{+20} ⬭

1 1 Which row shows characteristics of electric potential?

[1 mark]

	Vector or scalar	**Sign**	
A	Vector	Always negative	⬭
B	Vector	Positive or negative	⬭
C	Scalar	Always negative	⬭
D	Scalar	Positive or negative	⬭

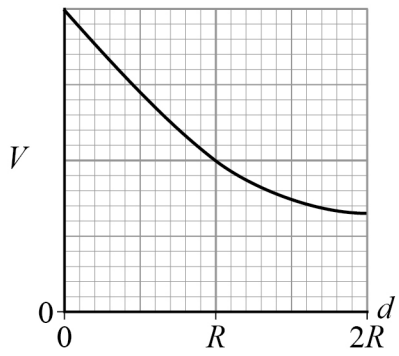
Do not write outside the box

1 2 In the graphs below, R is the radius of the Earth.

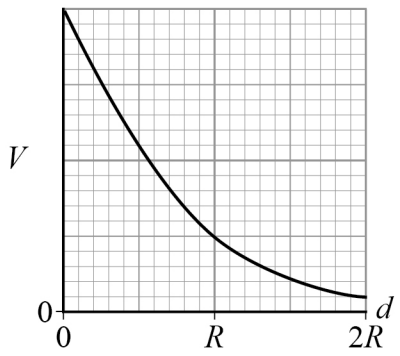
Which graph shows the variation of gravitational potential V with distance d from the surface of the Earth?

[1 mark]

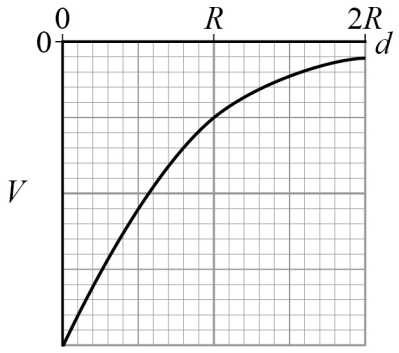
A



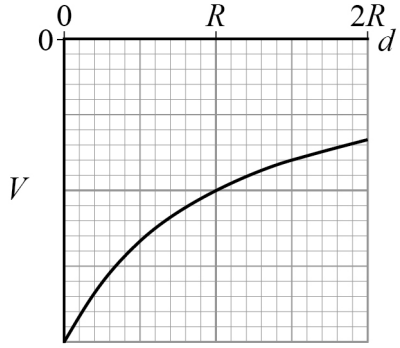
B



C



D



A ⬭

B ⬭

C ⬭

D ⬭

Turn over ►

Do not write outside the box

1 3 Ganymede and Io are two moons of Jupiter. The orbital radius of Ganymede is greater than the orbital radius of Io.

Which row shows the moon with the greater orbital speed and the moon with the greater angular speed?

[1 mark]

	Greater orbital speed	Greater angular speed	
A	Io	Io	⬭
B	Io	Ganymede	⬭
C	Ganymede	Io	⬭
D	Ganymede	Ganymede	⬭

1 4 A satellite moves from a high orbit into a lower orbit.

Which row describes the changes to the satellite's potential energy E_p and kinetic energy E_k?

[1 mark]

	E_p	E_k	
A	Increases	Increases	⬭
B	Increases	Decreases	⬭
C	Decreases	Increases	⬭
D	Decreases	Decreases	⬭

1 5 Gravitational field lines and lines of equipotential

[1 mark]

A are straight in a radial field. ⬭

B are curved in a radial field. ⬭

C intersect at 90^o only in uniform fields. ⬭

D intersect at 90^o in uniform and radial fields. ⬭

Do not write outside the box

1 6 Two point charges of magnitude Q are separated by a distance r. The electrostatic force experienced by each charge is F.

What force will be experienced by each of two point charges of magnitude $3Q$ separated by a distance $2r$?

[1 mark]

A $\frac{2F}{9}$ ⬭

B $\frac{4F}{9}$ ⬭

C $\frac{9F}{4}$ ⬭

D $\frac{9F}{2}$ ⬭

1 7 Which is **not** a unit for permittivity?

[1 mark]

A $\mathrm{C\ V^{-1}\ m^{-1}}$ ⬭

B $\mathrm{\Omega\ s\ m^{-1}}$ ⬭

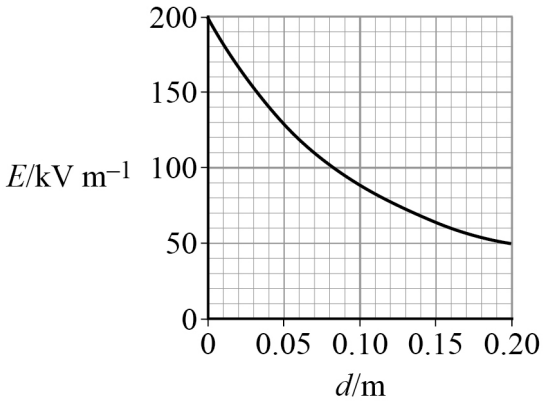
C $\mathrm{A\ s\ V^{-1}\ m^{-1}}$ ⬭

D $\mathrm{\Omega^{-1}\ s\ m^{-1}}$ ⬭

Turn over for the next question

Do not write outside the box

1 8 The graph shows the variation in electric field strength E with distance d from the surface of a charged sphere of radius $0.20\ \text{m}$.



What is the potential difference between a point on the surface of the sphere and a point $0.20\ \text{m}$ above the surface?

[1 mark]

A $20\ \text{kV}$ ⬭

B $40\ \text{kV}$ ⬭

C $50\ \text{kV}$ ⬭

D $150\ \text{kV}$ ⬭

1 9 A capacitor of capacitance C stores $1.90 \times 10^{-3}\ \text{J}$ of energy when it has a potential difference V across it.

What is the energy stored in a capacitor of capacitance $\frac{C}{3}$ when the potential difference across it is $3V$?

[1 mark]

A $6.3 \times 10^{-4}\ \text{J}$ ⬭

B $2.9 \times 10^{-3}\ \text{J}$ ⬭

C $5.7 \times 10^{-3}\ \text{J}$ ⬭

D $5.1 \times 10^{-2}\ \text{J}$ ⬭

Do not write outside the box

2 0 A capacitor C_1 is charged and then connected in parallel with a second, previously uncharged, capacitor.

Which statement is correct?

[1 mark]

A The energy stored in the parallel combination is equal to that originally stored in C_1. ⬭

B The potential difference across the parallel combination is equal to that originally across C_1. ⬭

C The capacitance of the parallel combination is the average of the capacitance of the two capacitors. ⬭

D The charge stored in the parallel combination is equal to that originally stored in C_1. ⬭

2 1 A capacitor discharges through a $22\ \text{k}\Omega$ resistor. It takes $0.75\ \text{s}$ for the potential difference across the capacitor to fall from $8.0\ \text{V}$ to $4.0\ \text{V}$.

What is the capacitance of the capacitor?

[1 mark]

A $34\ \mu\text{F}$ ⬭

B $49\ \mu\text{F}$ ⬭

C $68\ \mu\text{F}$ ⬭

D $98\ \mu\text{F}$ ⬭

2 2 A capacitor of capacitance $9.0\ \text{nF}$ has plates with an overlapping area of $18\ \text{cm}^2$ separated by a dielectric of thickness $0.15\ \text{mm}$.

What is the relative permittivity of the dielectric?

[1 mark]

A 8.5×10^1 ⬭

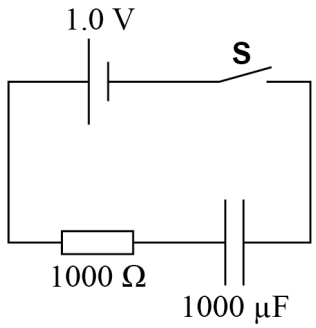
B 8.5×10^3 ⬭

C 7.5×10^6 ⬭

D 7.5×10^8 ⬭

Do not write outside the box

2 3 A capacitor is charged by closing switch **S**. The cell has an emf of $1.0\ \text{V}$ and a negligible internal resistance. The capacitor has a capacitance of $1000\ \mu\text{F}$ and the resistor has a resistance of $1000\ \Omega$.



What is the potential difference across the capacitor $1.0\ \text{s}$ after **S** is closed?

[1 mark]

A $0.37\ \text{mV}$ ⬭

B $0.63\ \text{mV}$ ⬭

C $0.37\ \text{V}$ ⬭

D $0.63\ \text{V}$ ⬭

2 4 The decay constant of a radioactive nuclide is equivalent to

[1 mark]

A the gradient of a graph of the number of nuclei in the sample against time. ⬭

B the gradient of a graph of the activity of the sample against time. ⬭

C the ratio of the activity of a sample to the number of nuclei of that nuclide in the sample. ⬭

D the ratio of the number of nuclei of that nuclide in the sample to the activity of a sample. ⬭

Do not write outside the box

2 5 In naturally-occurring carbon, most of the atoms are stable but one atom in 10^{12} is the radioactive isotope $^{14}_{6}C$. The decay constant for $^{14}_{6}C$ is 3.8×10^{-12} s^{-1}.
Carbon dioxide molecules each contain one atom of carbon.

What is the activity of the carbon in 0.25 mol of naturally-occurring carbon dioxide?

[1 mark]

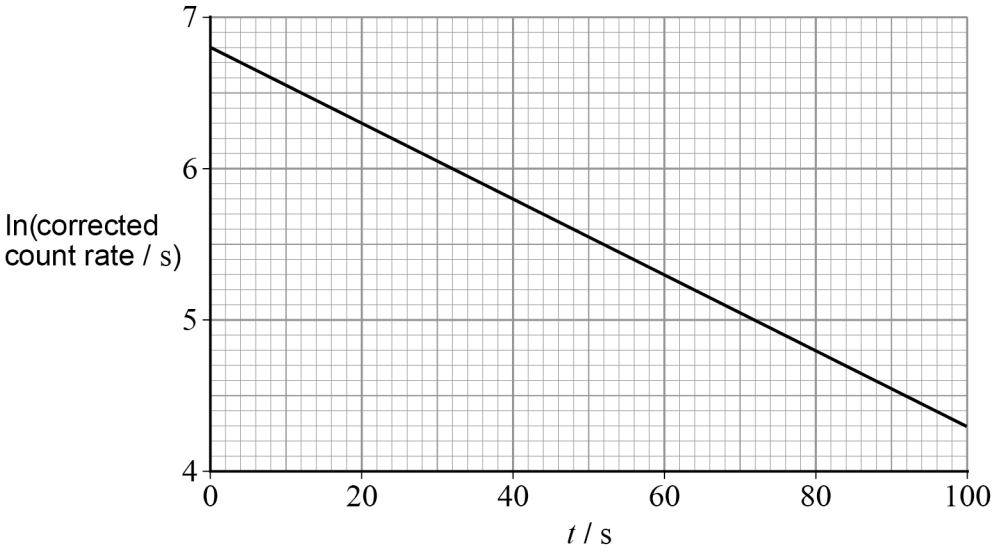
A 0.57 Bq ⬭

B 2.3 Bq ⬭

C 5.7×10^{11} Bq ⬭

D 2.3×10^{12} Bq ⬭

2 6 The graph shows the variation of ln(corrected count rate / s) with time for a radioactive source.



What is the half life of the nuclide from which the source is made?

[1 mark]

A 0.025 s ⬭

B 28 s ⬭

C 1.3×10^{8} s ⬭

D 8.7×10^{8} s ⬭

Turn over ►

Do not write outside the box

2 7 A magnetic field has a magnetic flux of $0.025\ \text{Wb}$ and an area of $0.25\ \text{m}^2$.
A conductor of length $8.0\ \text{cm}$ is parallel to the field and carries a current of $3.0\ \text{A}$.

What is the magnitude of the force experienced by the conductor?

[1 mark]

A $0\ \text{N}$ ⬭

B $1.5 \times 10^{-3}\ \text{N}$ ⬭

C $2.4 \times 10^{-2}\ \text{N}$ ⬭

D $2.4\ \text{N}$ ⬭

2 8 Which statement about units relating to magnetic fields is correct?

[1 mark]

A A tesla is the magnetic field needed to produce a force of $1\ \text{N}$ per second on a conductor of length $1\ \text{m}$ at 90^{o} to a magnetic field ⬭

B One tesla is equivalent to one V s m^{-2} ⬭

C A weber is the flux that induces an emf of $1\ \text{V}$ in a single turn of wire when the flux is quickly reduced to zero ⬭

D One weber is equivalent to one $\text{N A}^{-1}\ \text{m}^{-1}$ ⬭

2 9 A beta particle and an alpha particle are travelling with the same speed and direction in a magnetic field. The force experienced by the beta particle is $+F$.

What is the force experienced by the alpha particle?

[1 mark]

A $-2F$ ⬭

B $\dfrac{-F}{2}$ ⬭

C $\dfrac{+F}{2}$ ⬭

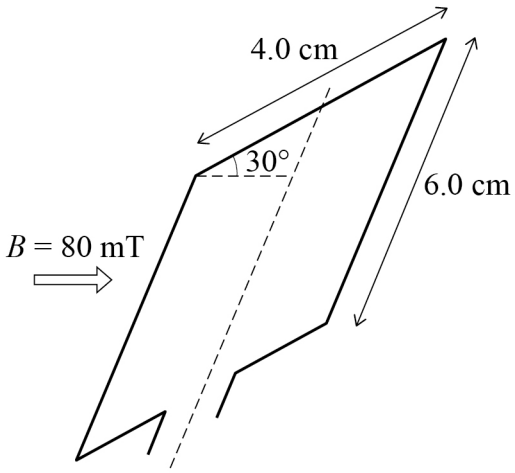
D $+2F$ ⬭

Do not write outside the box

3 0 A rectangular coil with 50 turns has a length of $6.0\ \text{cm}$ and a width of $4.0\ \text{cm}$. The plane of the coil is at 30° to a magnetic field of flux density $80\ \text{mT}$.

What is the flux linkage of the coil?

[1 mark]



A 9.6×10^{-5} Wb ⬭

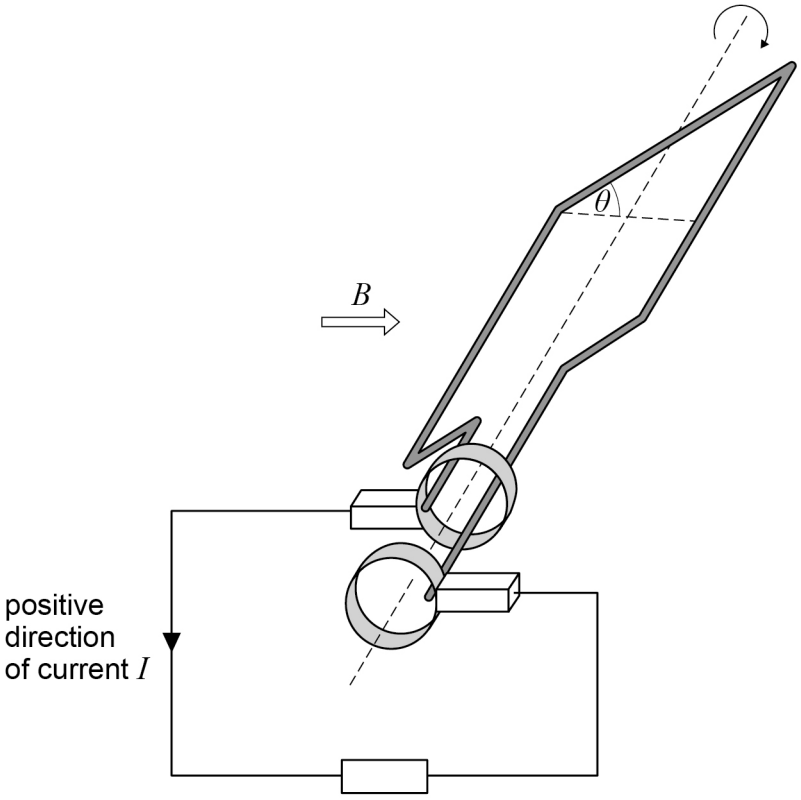
B 4.8×10^{-3} Wb ⬭

C 8.3×10^{-3} Wb ⬭

D 4.8×10^{0} Wb ⬭

Turn over for the next question

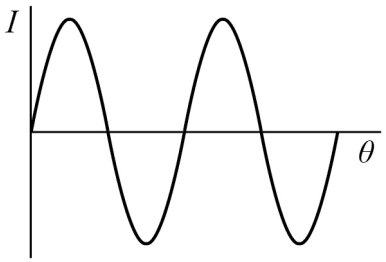
3 1 A current I is supplied by a coil rotating in a magnetic field of flux density B. The angle between the plane of the coil and the magnetic field is θ.



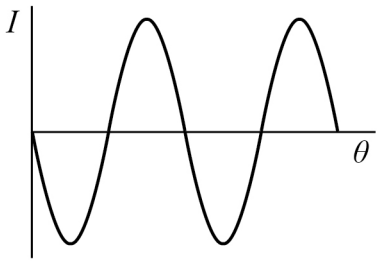
Which graph represents the variation of I with θ?

[1 mark]

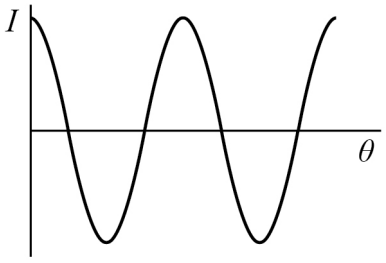
A



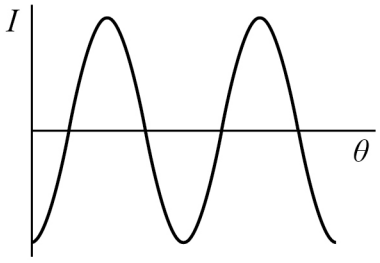
B



C



D



Do not write outside the box

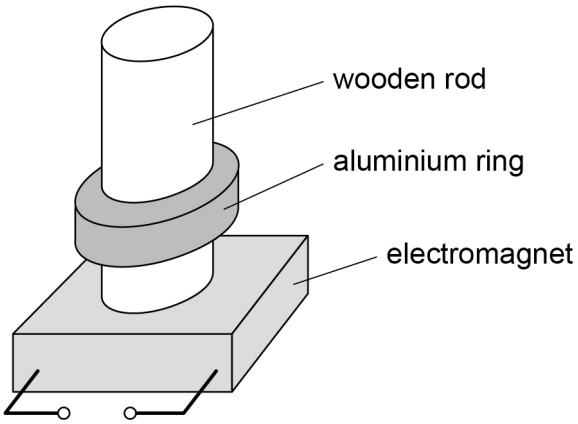
A ⬭

B ⬭

C ⬭

D ⬭

3 2 The diagram shows an experiment in which an electromagnet and an aluminium ring are being used to demonstrate electromagnetic induction.



Which statement is correct?

[1 mark]

A When dc is connected to the electromagnet, the ring experiences a steady repulsion from the electromagnet. ⬭

B When dc is connected to the electromagnet, the ring experiences a brief attraction to the electromagnet. ⬭

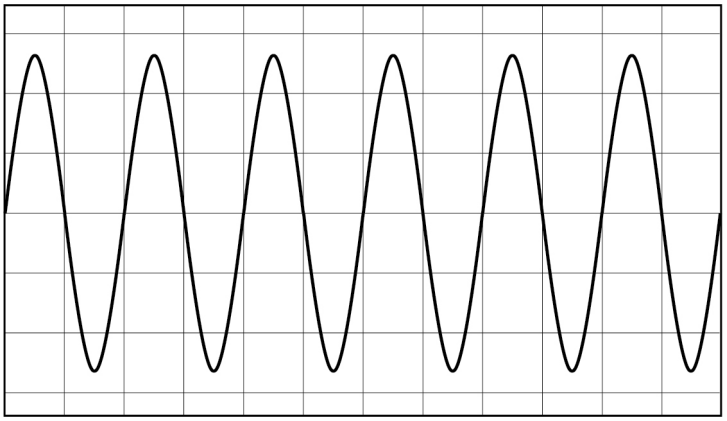
C When ac is connected to the electromagnet, an emf is induced in the ring causing it to be repelled from the electromagnet. ⬭

D When ac is connected to the electromagnet, an emf is induced in the ring causing it to vibrate up and down. ⬭

Turn over for the next question

Do not write outside the box

Questions **33** and **34** relate to the oscilloscope trace shown in the diagram below.



3 3 The time base is set to $2\ \mu s$ per scale division.

What is the frequency of the signal?

[1 mark]

A 230 kHz ⬭

B 250 kHz ⬭

C 280 kHz ⬭

D 490 kHz ⬭

3 4 The y–amplification is set to $0.2\ mV$ per scale division.

What is the root mean square voltage of the signal?

[1 mark]

A 0.37 mV ⬭

B 0.53 mV ⬭

C 0.74 mV ⬭

D 1.1 mV ⬭

Do not write outside the box

3 5 A transformer has 400 turns on the primary coil and 5000 turns on the secondary coil. The transformer is 93% efficient. The primary voltage is 12 V and the primary current is 4.8 A.

What is the magnitude of the secondary current?

[1 mark]

A 0.36 A ⬭

B 0.41 A ⬭

C 56 A ⬭

D 65 A ⬭

3 6 Which statement about transformer inefficiency is **not** correct?

[1 mark]

A I^2R losses can be minimised by using thicker wire for the coils. ⬭

B I^2R losses can be reduced by using soft iron wire for the coils. ⬭

C Flux losses reduce the induced emf in the secondary coil. ⬭

D Laminations of the core reduce eddy current losses. ⬭

30

END OF QUESTIONS

Do not write outside the box

There are no questions printed on this page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED