Centre Number						Candidate Number					
Surname											
Other Names											
Candidate Signature											

AQA

General Certificate of Education
Advanced Level Examination
June 2015

Physics A   PHYA4/1

Unit 4   Fields and Further Mechanics
Section A

Thursday 11 June 2015   9.00 am to 10.45 am

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.

PHYA4/1

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 Which one of the following has the same unit as the rate of change of momentum?

    A   work

    B   energy

    C   acceleration

    D   weight

2 The nucleus of a radioactive isotope X is at rest and decays by emitting an α particle so that a new nuclide Y is formed.
Which one of the following statements about the decay is correct?

    A   The momentum of Y is equal and opposite to the momentum of the α particle.

    B   The momentum of Y is equal to the momentum of X.

    C   The kinetic energy of Y is equal to the kinetic energy of the α particle.

    D   The total kinetic energy is the same before and after the decay.

3 Trolley T_1, of mass $2.0 \ \text{kg}$, collides on a horizontal surface with trolley T_2, which is also of mass $2.0 \ \text{kg}$. The collision is elastic. Before the collision T_1 was moving at $4.0 \ \text{m s}^{-1}$ and T_2 was at rest.
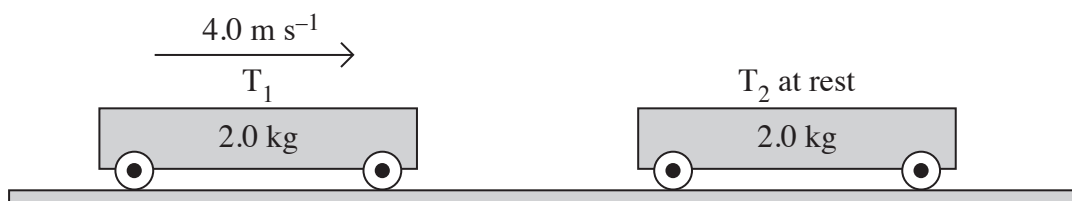
Which one of the following statements is correct?

Immediately after the collision

    A T_1 is at rest and T_2 moves at $4.0 \ \text{m s}^{-1}$.

    B T_1 will rebound from T_2 at $4.0 \ \text{m s}^{-1}$.

    C T_1 and T_2 will both move at $2.8 \ \text{m s}^{-1}$.

    D T_1 and T_2 will both move at $1.4 \ \text{m s}^{-1}$.

4 For a body performing simple harmonic motion, which one of the following statements is correct?

    A The maximum kinetic energy is directly proportional to the frequency.

    B The time for one oscillation is directly proportional to the frequency.

    C The speed at any instant is directly proportional to the displacement.

    D The maximum acceleration is directly proportional to the amplitude.

5 Which one of the following graphs shows how the acceleration, a, of a body moving with simple harmonic motion varies with its displacement, x?

    A   **B**   **C**   **D**
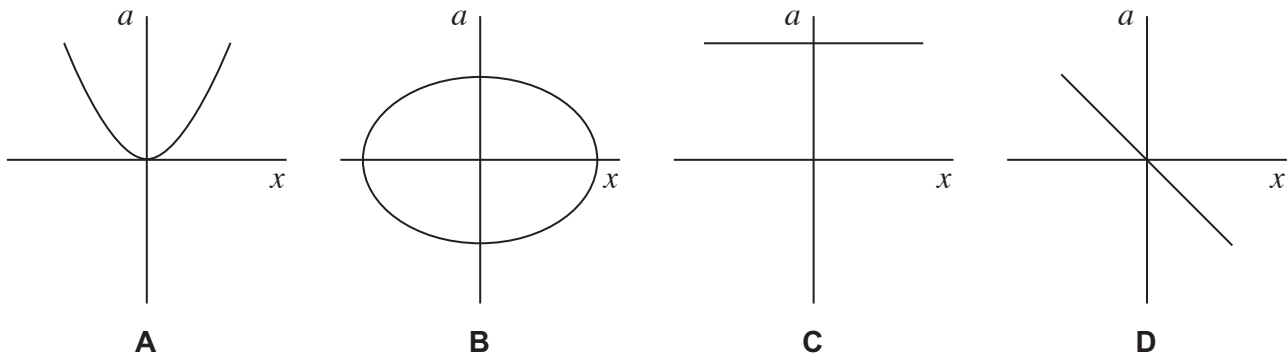
6 A particle of mass 5.0×10^{-3} kg, moving with simple harmonic motion of amplitude 0.15 m, takes 47 s to make 50 oscillations.
What is the maximum kinetic energy of the particle?

    A 2.0×10^{-3} J

    B 2.5×10^{-3} J

    C 3.9×10^{-3} J

    D 5.0×10^{-3} J

7 A simple pendulum has a time period of 1.42 s on Earth. The gravitational field strength at the surface of Mars is 0.37 times that at the surface of the Earth.
What is the time period of the pendulum on Mars?

    A   0.53 s

    B   0.86 s

    C   2.33 s

    D   3.84 s

Turn over ▶

8 Two identical uniform spheres each of radius R are placed in contact. The gravitational force between them is F.

The spheres are now separated until the force of attraction is $\dfrac{F}{9}$.

What is the distance between the **surfaces** of the spheres after they have been separated?

A $2R$

B $4R$

C $8R$

D $12R$

9 A satellite of mass m is in a circular orbit at height R above the surface of a uniform spherical planet of radius R and density ρ.

What is the force of gravitational attraction between the satellite and the planet?

A $\dfrac{\pi\rho GmR}{3}$

B $\dfrac{2\pi\rho GmR}{3}$

C $\dfrac{\pi\rho GmR^2}{3}$

D $\dfrac{2\pi\rho GmR^2}{3}$

10 The following data refer to two planets, P and Q.

	Radius / km	Density / kg m^{-3}
planet P	8000	6000
planet Q	16 000	3000

The gravitational field strength at the surface of P is 13.4 N kg^{-1}.
What is the gravitational field strength at the surface of Q?

A 3.4 N kg^{-1}

B 13.4 N kg^{-1}

C 53.6 N kg^{-1}

D 80.4 N kg^{-1}

11 The diagram shows an isolated binary star system. The two stars have equal masses, M, and the distance between their centres is r.
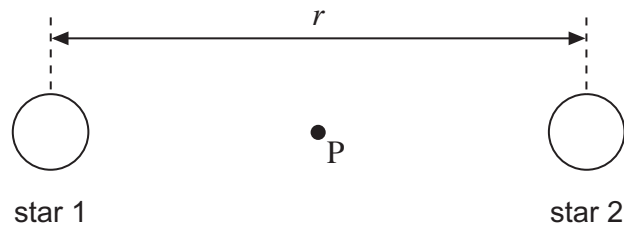
The point P is half-way between the two stars.
What is the gravitational field strength at P?

A zero

B $-\dfrac{GM}{r^2}$

C $-\dfrac{2GM}{r^2}$

D $-\dfrac{4GM}{r^2}$

12 Which one of the following statements about gravitational potential is **incorrect**?

A It is analogous to the electric potential at a point in an electric field.

B It is equal to the gravitational potential energy of a mass of 1 kg.

C It is a vector quantity.

D The difference in gravitational potential between two points at different heights above the Earth depends on the position of the points.

Turn over ▶

13 A satellite X is in a circular orbit of radius r about the centre of a spherical planet of mass M.
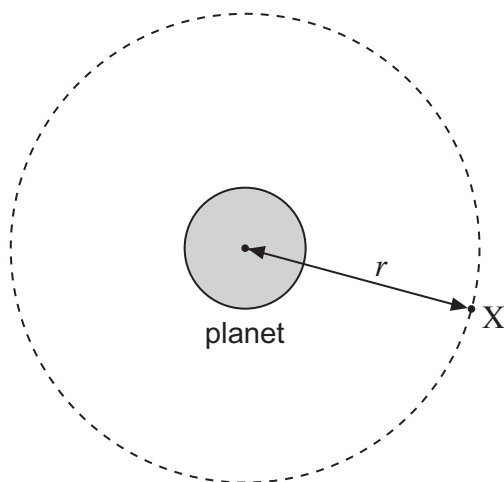
Which line, **A** to **D**, in the table gives correct expressions for the centripetal acceleration a and the speed v of the satellite?

	Centripetal acceleration a	Speed v
A	$\dfrac{GM}{2r}$	$\sqrt{\dfrac{GM}{2r}}$
B	$\dfrac{GM}{2r}$	$\sqrt{\dfrac{GM}{r}}$
C	$\dfrac{GM}{r^2}$	$\sqrt{\dfrac{GM}{2r}}$
D	$\dfrac{GM}{r^2}$	$\sqrt{\dfrac{GM}{r}}$

14 A satellite orbiting the Earth moves to an orbit which is closer to the Earth.

Which line, **A** to **D**, in the table shows correctly what happens to the speed of the satellite and to the time it takes for one orbit of the Earth?

	Speed of satellite	Time for one orbit of Earth
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

15 A positive ion has a charge-to-mass ratio of $2.40 \times 10^7 \text{ C kg}^{-1}$. It is held stationary in a vertical electric field.
Which line, **A** to **D**, in the table shows correctly both the strength and the direction of the electric field?

	Electric field strength / V m^{-1}	Direction
A	4.09×10^{-7}	upwards
B	4.09×10^{-7}	downwards
C	2.45×10^6	upwards
D	2.45×10^6	downwards

16 In the equation $X = \dfrac{ab}{r^n}$, X represents a physical variable in an electric or a gravitational field, a is a constant, b is either mass or charge and n is a number.

Which line, **A** to **D**, in the table provides a consistent representation of X, a and b according to the value of n?

The symbols E, g, V and r have their usual meanings.

	n	X	a	b
A	1	E	$\dfrac{1}{4\pi\varepsilon_0}$	charge
B	1	V	$\dfrac{1}{4\pi\varepsilon_0}$	mass
C	2	g	G	mass
D	2	V	G	charge

17 An uncharged 4.7 nF capacitor is connected to a 1.5 V supply and becomes fully charged.

How many electrons are transfered to the negative plate of the capacitor during this charging process?

A 2.2×10^{10}

B 3.3×10^{10}

C 4.4×10^{10}

D 8.8×10^{10}

Turn over ▶

18   When fully charged the 2.0 mF capacitor used as a backup for a memory unit has a potential difference of 5.0 V across it. The capacitor is required to supply a constant current of 1.0 μA and can be used until the potential difference across it falls by 10%. For how long can the capacitor be used before it must be recharged?

   A 10 s

   B 100 s

   C 200 s

   D 1000 s

19   A capacitor of capacitance 10 μF is charged through a resistor R to a potential difference (pd) of 20 V using the circuit shown.
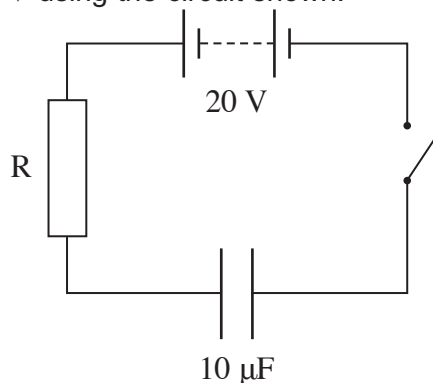
   When the capacitor is fully charged which one of the following statements is **incorrect**?

   A   The energy stored by the capacitor is 2 mJ.

   B   The total energy taken from the battery during the charging process is 2 mJ.

   C   The pd across the capacitor is 20 V.

   D   The pd across the resistor is 0 V.

20   The diagram shows a rigidly-clamped straight horizontal current-carrying wire held mid-way between the poles of a magnet on a top-pan balance. The wire is perpendicular to the magnetic field direction.
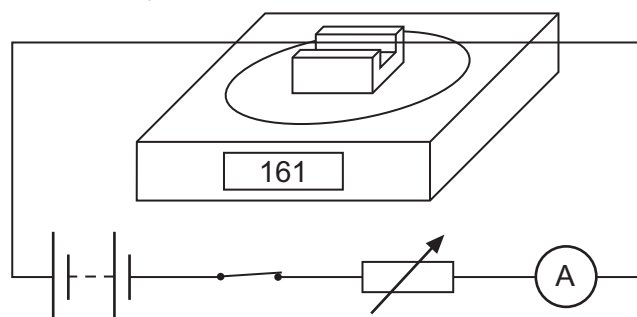
   The balance, which was zeroed before the switch was closed, read 161 g after the switch was closed. When the current is reversed and doubled, what would be the new reading on the balance?

   A -322 g

   B -161 g

   C   zero

   D 322 g

21 Four rectangular loops of wire **A**, **B**, **C** and **D** are each placed in a uniform magnetic field of the same flux density B. The direction of the magnetic field is parallel to the plane of the loops as shown.

When a current of 1 A is passed through each of the loops, magnetic forces act on them. The lengths of the sides of the loops are as shown.
Which loop experiences the largest couple?
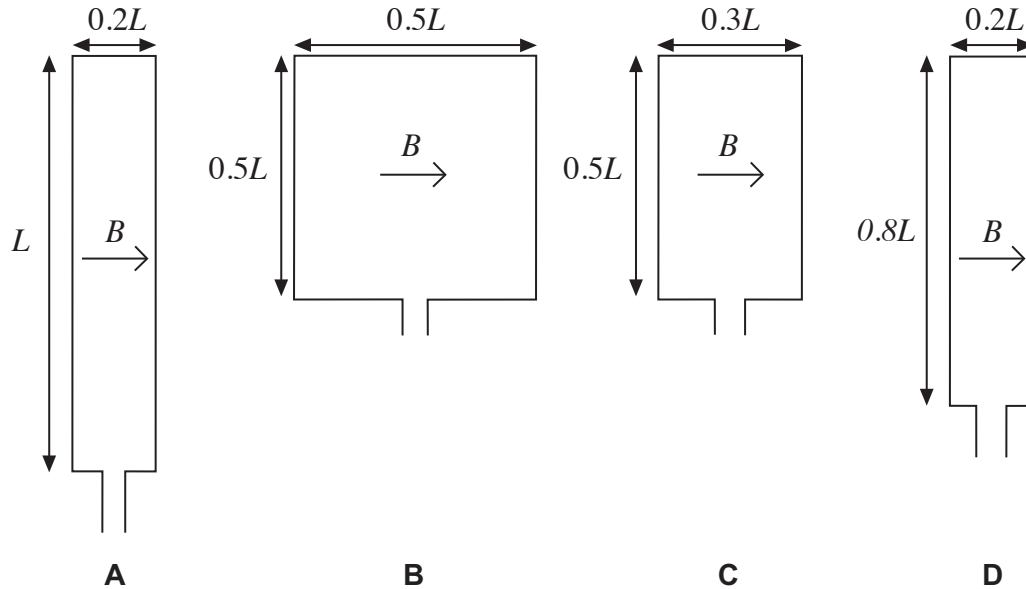
22 Which one of the following statements is correct?

An electron follows a circular path when it is moving at right angles to

A a uniform magnetic field.

B a uniform electric field.

C uniform electric and magnetic fields which are perpendicular.

D uniform electric and magnetic fields which are in opposite directions.

Turn over ▶

23   Two electrons, X and Y, travel at right angles to a uniform magnetic field.
X experiences a magnetic force, F_X, and Y experiences a magnetic force, F_Y.

What is the ratio $\dfrac{F_X}{F_Y}$ if the kinetic energy of X is half that of Y?

A $\dfrac{1}{4}$

B $\dfrac{1}{2}$

C $\dfrac{1}{\sqrt{2}}$

D   1

24   A lamp rated at 12 V 60 W is connected to the secondary coil of a step-down transformer and is at full brightness. The primary coil is connected to a supply of 230 V. The transformer is 75% efficient.
What is the current in the primary coil?

A   0.25 A

B   0.35 A

C   3.75 A

D   5.0 A

25   The overhead cables used to transmit electrical power by the National Grid usually consist of a central core of steel cables surrounded by a sheath of cables of low resistivity material, such as aluminium.

sheath of low resistivity cables

core of steel cables
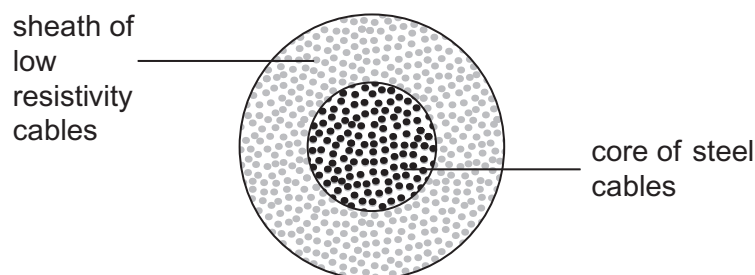
What is the main purpose of the steel core?

A   to force more current into the outer sheath

B   to provide additional current paths through the cables

C   to reduce the power lost from the cables

D   to increase the mechanical strength of the cables

END OF SECTION A

Surname	
Other Names	
Candidate Signature	

Physics A   **PHYA4/2**

Unit 4   **Fields and Further Mechanics**
Section B

Thursday 11 June 2015   9.00 am to 10.45 am

For this paper you must have:
- a calculator
- a pencil and a ruler
- a Data and Formulae Booklet (enclosed).

For Examiner's Use

Examiner's Initials

Question	Mark
1	
2	
3	
4	
5	
TOTAL	

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

1 (a) A mass is attached to one end of a spring and the other end of the spring is suspended from a support rod, as shown in **Figure 1**.

Figure 1

support rod
oscillating
vertically

spring
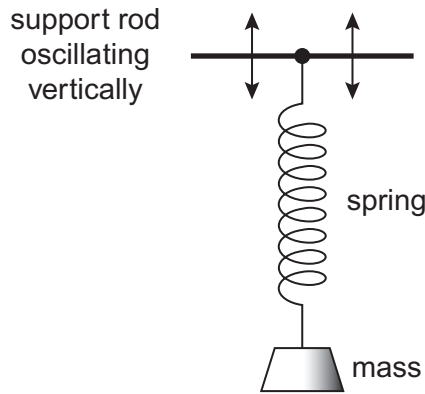
mass

The support rod oscillates vertically, causing the mass to perform forced vibrations. Under certain conditions, the system may demonstrate resonance.

Explain in your answer what is meant by forced vibrations and resonance. You should refer to the frequency, amplitude and phase of the vibrations.

[4 marks]

forced vibrations ....

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resonance ....

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1 (b) A simple pendulum is set up by suspending a light paper cone (acting as the pendulum bob) on the end of a length of thin thread. A metal ring may be placed over the cone to increase the mass of the bob, as shown in **Figure 2**.

Figure 2
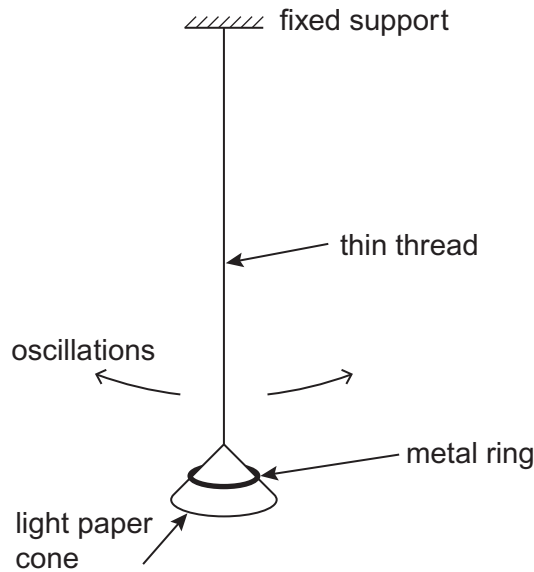
The bob is displaced and released so that it oscillates in a vertical plane. The oscillations are subject to damping.

1 (b) (i) Are the oscillations of the pendulum more heavily damped when the cone oscillates with the metal ring on it, when it oscillates without the ring, or does the presence of the ring have no effect on the damping of the oscillations? Tick (✓) the correct answer.

[1 mark]

cone oscillates with ring	
cone oscillates without ring	
ring has no effect	

1 (b) (ii) Explain your answer to part (b)(i).

[3 marks]

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Turn over ▶

2 (a)   State, in words, Coulomb's law.

[2 marks]

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2 (b)   **Figure 3** shows how the electric potential, V, varies with $\frac{1}{r}$, where r is the distance from a point charge Q.

Figure 3
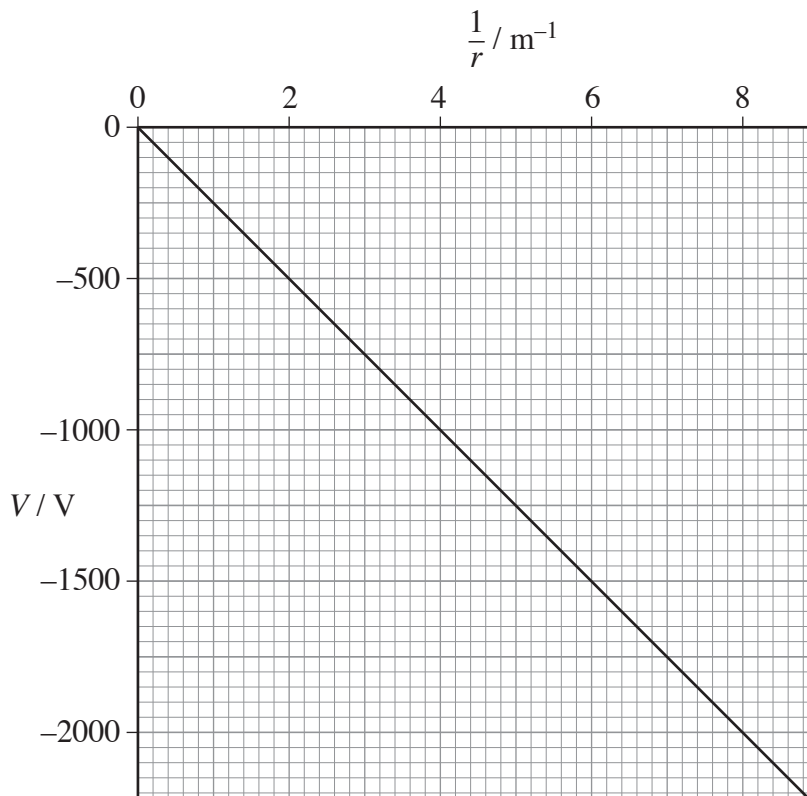
State what can be deduced from the graph about how V depends on r and explain why all the values of V on the graph are negative.

[2 marks]

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2 (c) (i)   Use data from the graph (**Figure 3**) to show that the magnitude of Q is about 30 nC.

[2 marks]

2 (c) (ii)   A +60 nC charge is moved from a point where $r = 0.20$ m to a point where $r = 0.50$ m. Calculate the work done.

[2 marks]

work done .... J

2 (c) (iii)   Calculate the electric field strength at the point where $r = 0.40$ m.

[2 marks]

electric field strength .... V m^{-1}

Turn over ▶

3 (a) **Figure 4** shows how the current varies with time as a capacitor is discharged through a 150 Ω resistor.

Figure 4
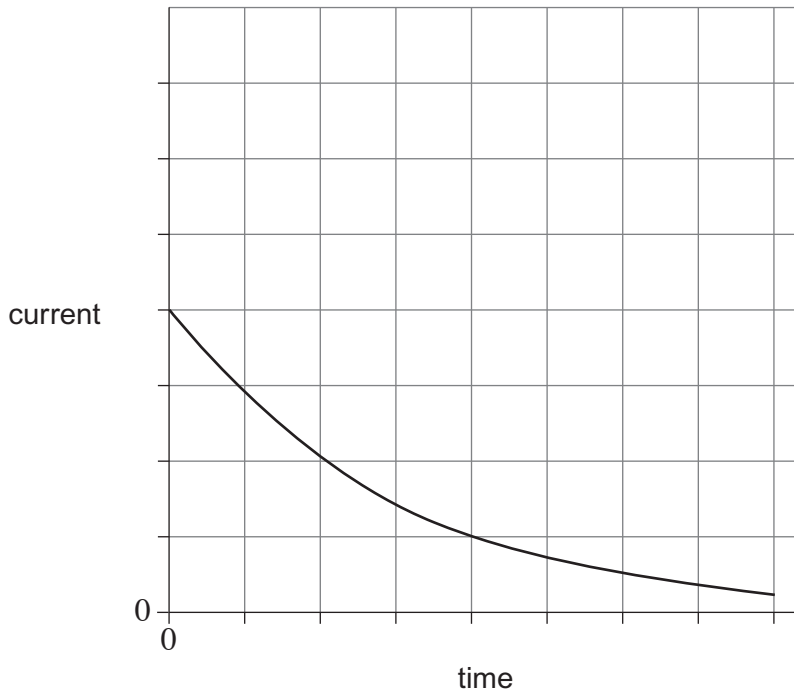
3 (a) (i) Explain how the initial charge on the capacitor could be determined from a graph of current against time.

[1 mark]

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3 (a) (ii) The same capacitor is charged to the same initial potential difference (pd) and then discharged through a $300 \text{ k}\Omega$ resistor. Sketch a second graph on the same axes above to show how the current varies with time in this case.

[3 marks]

3 (b) In an experiment to show that a capacitor stores energy, a student charges a capacitor from a battery and then discharges it through a small electric motor. The motor is used to lift a mass vertically.

3 (b) (i) The capacitance of the capacitor is 0.12 F and it is charged to a pd of 9.0 V.
The weight of the mass raised is 3.5 N.
Calculate the maximum height to which the mass could be raised.
Give your answer to an appropriate number of significant figures.

[4 marks]

maximum height .... m

3 (b) (ii) Give **two** reasons why the value you have calculated in part (b)(i) would not be achieved in practice.

[2 marks]

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10

Turn over ▶

4 (a) **Figure 5** shows two coils, **P** and **Q**, linked by an iron bar. Coil **P** is connected to a battery through a variable resistor and a switch **S**. Coil **Q** is connected to a centre-zero ammeter.

Figure 5
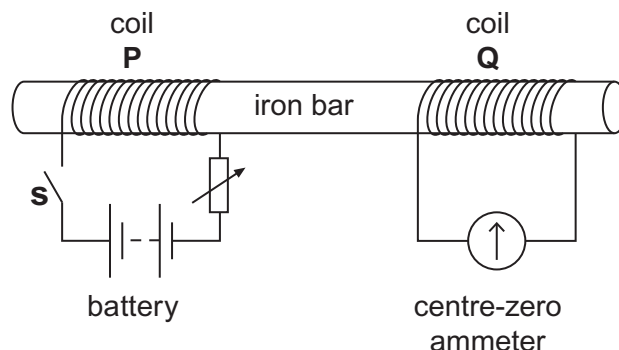
4 (a) (i) Initially the variable resistor is set to its minimum resistance and **S** is open. Describe and explain what is observed on the ammeter when **S** is closed.

[3 marks]

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4 (a) (ii) With **S** still closed, the resistance of the variable resistor is suddenly increased. Compare what is now observed on the ammeter with what was observed in part (a)(i). Explain why this differs from what was observed in part (a)(i).

[2 marks]

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4 (b) **Figure 6** shows a 40-turn coil of cross-sectional area 3.6×10^{-3} m^2 with its plane set at right angles to a uniform magnetic field of flux density 0.42 T.

Figure 6
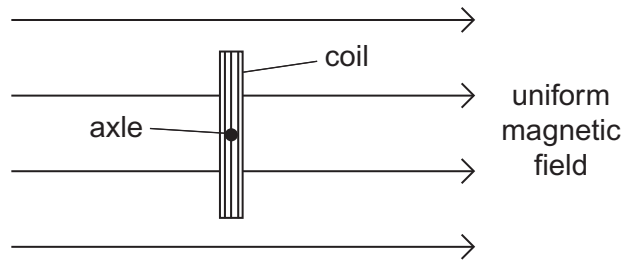
4 (b) (i) Calculate the magnitude of the magnetic flux linkage for the coil.
State an appropriate unit for your answer.

[2 marks]

flux linkage .... unit ....

4 (b) (ii) The coil is rotated through $90°$ in a time of 0.50 s.
Determine the mean emf in the coil.

[2 marks]

mean emf V

Turn over ▶

9

5 A lead ball of mass 0.25 kg is swung round on the end of a string so that the ball moves in a horizontal circle of radius 1.5 m. The ball travels at a constant speed of 8.6 m s^{-1}.

5 (a) (i) Calculate the angle, in degrees, through which the string turns in 0.40 s.

[3 marks]

angle .... degree

5 (a) (ii) Calculate the tension in the string.
You may assume that the string is horizontal.

[2 marks]

tension .... N

5 (b) The string will break when the tension exceeds 60 N.
Calculate the number of revolutions that the ball makes in one second when the tension is 60 N.

[2 marks]

number of revolutions ....

5 (c) Discuss the motion of the ball in terms of the forces that act on it. In your answer you should:

- explain how Newton's three laws of motion apply to its motion in a circle
- explain why, in practice, the string will not be horizontal.

You may wish to draw a diagram to clarify your answer.

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

[6 marks]

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Turn over ▶

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END OF QUESTIONS

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