AQA

Please write clearly in block capitals.

Centre number						Candidate number				

Surname ____________________

Forename(s) ____________________

Candidate signature ____________________

A-level
PHYSICS A

Unit 4 Fields and Further Mechanics
Section A

Monday 20 June 2016 Morning

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.

Materials

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.

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

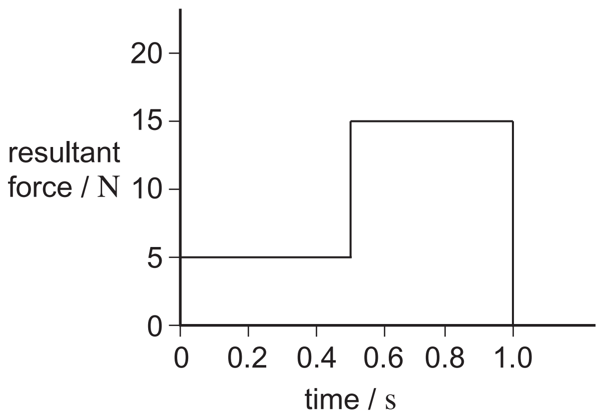
Each of Questions **1** to **25** is followed by four responses, **A**, **B**, **C**, and **D**. For each question select the best response and mark its letter on the answer sheet.

You are advised to spend about **45 minutes** on this section.

1 Which line, **A** to **D**, in the table correctly shows what is conserved in an elastic collision?

	Mass	**Momentum**	**Kinetic energy**	**Total energy**
A	conserved	not conserved	conserved	conserved
B	not conserved	conserved	conserved	not conserved
C	conserved	conserved	not conserved	conserved
D	conserved	conserved	conserved	conserved

2 The graph shows how the resultant force applied to an object of mass 2.0 kg, initially at rest, varies with time.



What is the speed of the object after 1.0 s?

A 2.5 m s^{-1}

B 5.0 m s^{-1}

C 7.5 m s^{-1}

D 10 m s^{-1}

3 What is the angular speed of a car wheel of diameter 0.400 m when the speed of the car is 108 km h^{-1}?

A 75 rad s^{-1}

B 150 rad s^{-1}

C 270 rad s^{-1}

D 540 rad s^{-1}

4 A ball of mass $0.30\ \text{kg}$ is attached to a string and moves in a **vertical** circle of radius $0.60\ \text{m}$ at a constant speed of $5.0\ \text{m s}^{-1}$.

Which line, **A** to **D**, in the table gives the correct values of the minimum and maximum tension in the string?

	Minimum tension / N	Maximum tension / N
A	2.5	5.4
B	6.7	9.6
C	13	13
D	9.6	15

5 Which one of the following statements is true when an object performs simple harmonic motion about a central point?

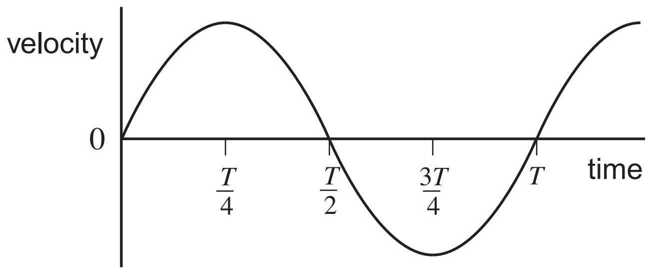
A The acceleration is always directed away from the central point.

B The acceleration and velocity are always 180° out of phase.

C The velocity and displacement are always in the same direction.

D Acceleration and displacement are always 180° out of phase.

6 The graph shows how velocity changes with time for a simple pendulum moving with simple harmonic motion.



Which one of the following statements related to the motion of the pendulum is **incorrect**?

A The acceleration is a minimum at $\frac{T}{4}$.

B The acceleration is a maximum at $\frac{T}{2}$.

C The kinetic energy is a maximum at $\frac{T}{2}$.

D The restoring force is a minimum at $\frac{3T}{4}$.

7 A mass hanging 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 both the top and bottom of the oscillation

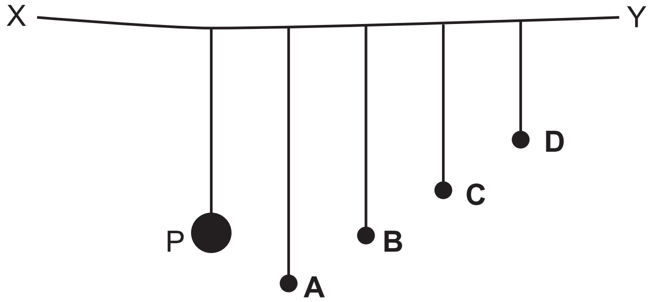
B only at the top of the oscillation

C only at the bottom of the oscillation

D at the centre of the oscillation

Turn over ▶

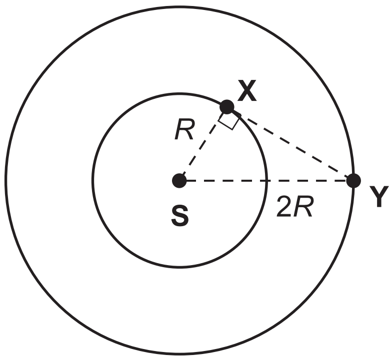
8 The diagram shows a string XY supporting a heavy pendulum P and four pendulums **A**, **B**, **C** and **D** of smaller mass.



Pendulum P is set in oscillation perpendicular to the plane of the diagram.

Which one of the pendulums, **A** to **D**, then oscillates with the largest amplitude?

9 Two planets **X** and **Y** are in concentric circular orbits about a star **S**. The radius of the orbit of **X** is R and the radius of orbit of **Y** is $2R$.



The gravitational force between **X** and **Y** is F when angle **SXY** is 90°, as shown in the diagram.
What is the gravitational force between **X** and **Y** when they are nearest to each other?

A $2F$

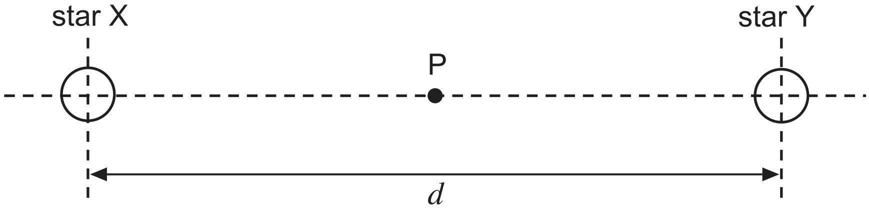
B $3F$

C $4F$

D $5F$

Do not write outside the box

10 X and Y are two stars of equal mass M. The distance between their centres is d.



What is the gravitational potential at the mid-point P between them?

A $\frac{GM}{2d}$

B $-\frac{GM}{d}$

C $-\frac{4GM}{d}$

D $-\frac{8GM}{d}$

11 A geosynchronous satellite is in a constant radius orbit around the Earth. The Earth has a mass of 6.0×10^{24} kg and a radius of 6.4×10^{6} m.

What is the height of the satellite above the Earth's surface?

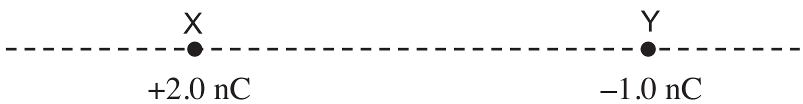
A 1.3×10^{7} m

B 3.6×10^{7} m

C 4.2×10^{7} m

D 4.8×10^{7} m

12 A +2.0 nC point charge X is at a fixed distance from a –1.0 nC point charge Y. The force between the two charges is F.

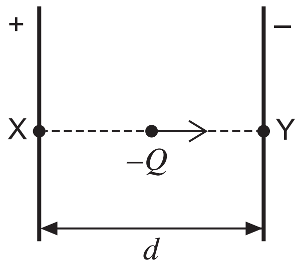


If an **additional** charge of +2.0 nC is supplied to both X and Y, which line, **A** to **D**, in the table gives the magnitude and direction of the force on X?

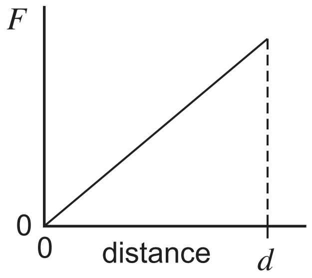
	Magnitude	**Direction**
A	2 F	from X to Y
B	4 F	from X to Y
C	2 F	from Y to X
D	4 F	from Y to X

Turn over ▶

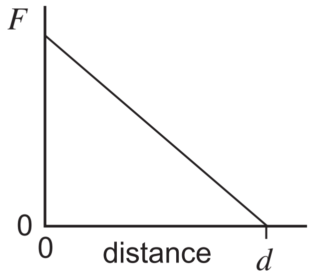
13 The diagram shows a charge $-Q$ being moved from point X to point Y between two charged parallel plates separated by a distance d.



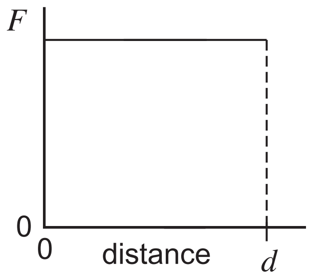
Which one of the following graphs best illustrates how the magnitude of force F on the charge varies with distance as it moves towards Y?



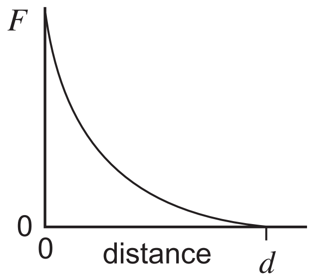
A



B

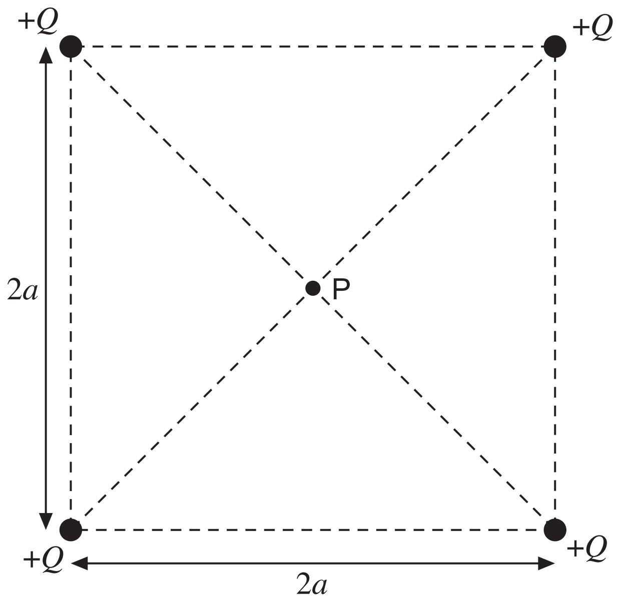


C



D

14 The diagram shows four point charges, each $+Q$, at the corners of a square of side $2a$.



What is the electric field strength at P, the centre of the square?

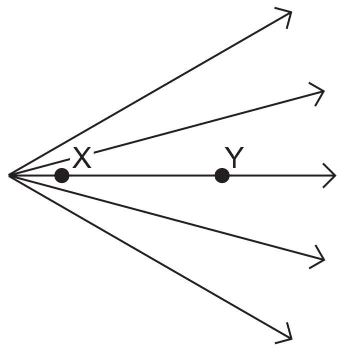
A zero

B $\dfrac{Q}{4\pi\varepsilon_0 a^2}$

C $\dfrac{Q}{2\pi\varepsilon_0 a^2}$

D $\dfrac{Q}{\pi\varepsilon_0 a^2}$

15 The diagram shows the field lines in a region of an electric field created by a positive charge.



Which one of the following statements is correct?
When moving from X to Y

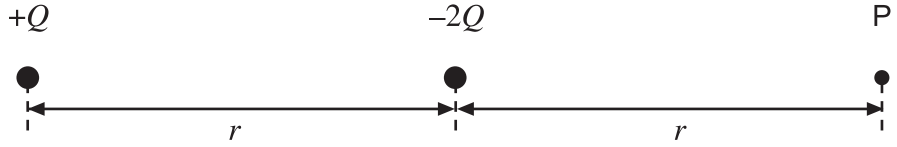
A the electric potential is constant.

B the electric potential increases.

C the electric potential decreases.

D the electric potential changes from positive to negative.

16 The diagram shows two point charges of magnitude $+Q$ and $-2Q$ placed a distance r apart.



What is the electric potential at point P, a distance r to the right of the $-2Q$ charge?

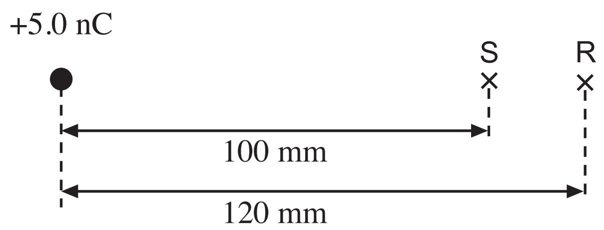
A $-\dfrac{3Q}{8\pi\varepsilon_0 r}$

B $-\dfrac{Q}{2\pi\varepsilon_0 r}$

C $+\dfrac{Q}{8\pi\varepsilon_0 r}$

D $+\dfrac{5Q}{8\pi\varepsilon_0 r}$

17



The potentials at points R and S due to the +5.0 nC charge are 375 V and 450 V respectively.

How much work is done when a +2.0 nC charge is moved from R to S?

A 0.12 μJ

B 0.15 μJ

C 0.19 μJ

D 0.38 μJ

18 The gravitational constant, G, is a constant of proportionality in Newton's law of gravitation. The permittivity of free space, ε_0, is a constant of proportionality in Coulomb's law.

When comparing the electrostatic force acting on a pair of charged particles to the gravitational force between them, the product $\varepsilon_0 G$ can appear in the calculation.

Which is a unit for $\varepsilon_0 G$?

A $C^2\ kg^{-2}$

B $C^2\ m^{-2}$

C $F\ kg^2\ N^{-1}\ m^{-2}$

D it has no unit

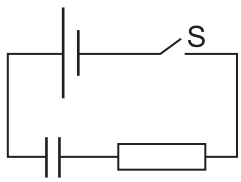
19 A variable capacitor has a capacitance which can be varied from 6.0×10^{-12} F to 3.0×10^{-12} F. The capacitor is set to its maximum capacitance and fully charged using a 48 V supply. The capacitor is then disconnected from the supply and isolated. Finally the capacitance is reduced to its minimum value without any charge being lost by the capacitor.

Which line, **A** to **D**, in the table correctly shows the potential difference (pd) across the capacitor and the charge it stores after the capacitance has been reduced?

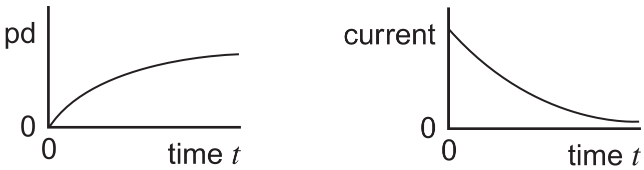
	pd / V	**Charge / C**
A	48	2.9×10^{-10}
B	24	2.9×10^{-10}
C	96	2.9×10^{-10}
D	96	1.4×10^{-10}

20 The capacitor in the circuit is initially uncharged. The switch S is closed at time t = 0.

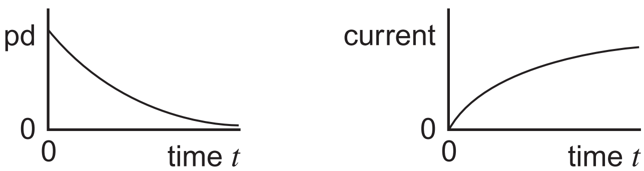
Which pair of graphs, **A** to **D**, correctly shows how the pd across the capacitor and the current in the circuit change with time?



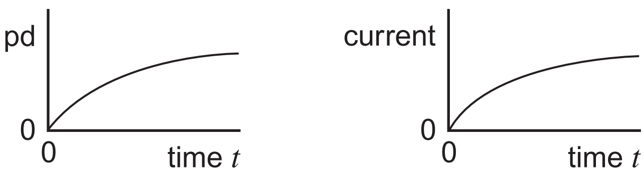
A



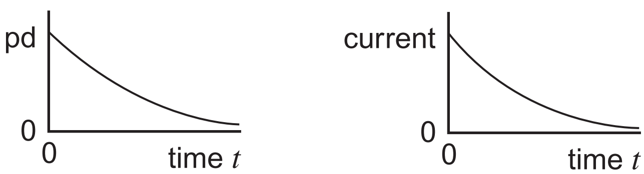
B



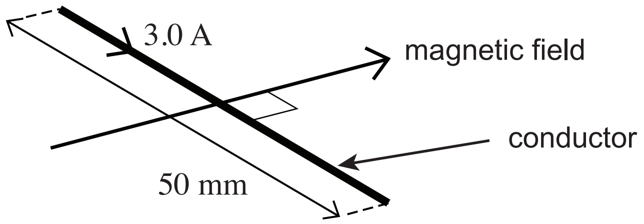
C



D



21 The diagram shows a horizontal conductor of length 50 mm carrying a current of 3.0 A at right angles to a uniform horizontal magnetic field of flux density 0.50 T.



What is the magnitude and direction of the magnetic force on the conductor ?

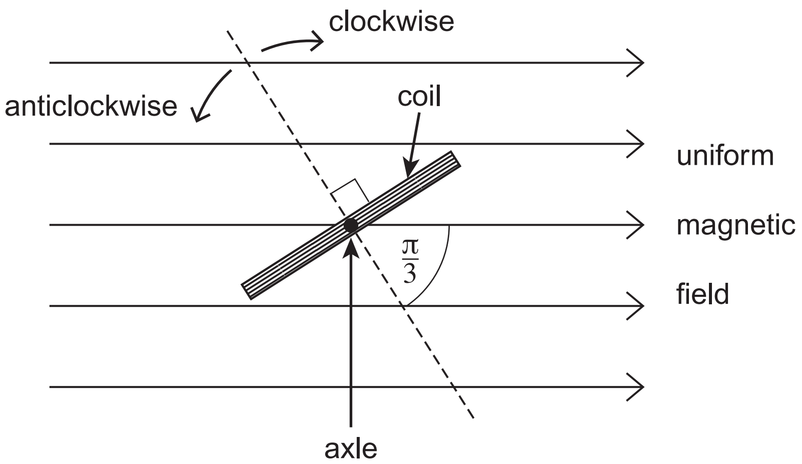
A 0.075 N vertically upwards

B 0.075 N vertically downwards

C 75 N vertically upwards

D 75 N vertically downwards

22 The diagram shows a coil placed in a uniform magnetic field. In the position shown, the angle between the normal to the plane of the coil and the magnetic field is $\frac{\pi}{3}$ rad.



Which line, **A** to **D**, in the table shows the angles through which the coil should be rotated, and the direction of rotation, so that the flux linkage becomes (i) a maximum, and (ii) a minimum?

	Angle of rotation / rad	
	(i) for maximum flux linkage	**(ii) for minimum flux linkage**
A	$\frac{\pi}{6}$ clockwise	$\frac{\pi}{3}$ anticlockwise
B	$\frac{\pi}{6}$ anticlockwise	$\frac{\pi}{3}$ clockwise
C	$\frac{\pi}{3}$ clockwise	$\frac{\pi}{6}$ anticlockwise
D	$\frac{\pi}{3}$ anticlockwise	$\frac{\pi}{6}$ clockwise

23 A train is travelling at $20\ \text{m s}^{-1}$ along a horizontal track through a uniform magnetic field of flux density 4.0×10^{-5} T acting vertically downwards.

What is the emf induced between the ends of an axle 1.5 m long?

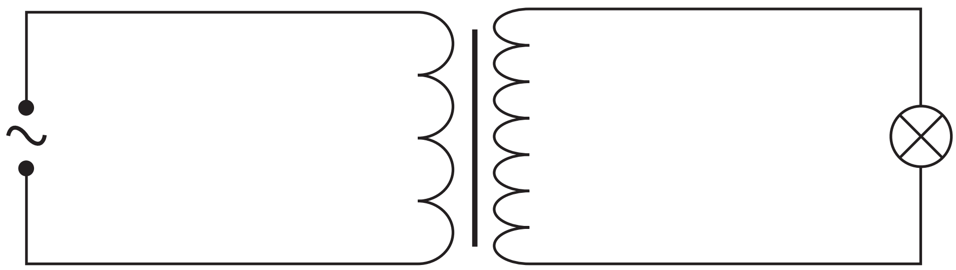
A 3.0×10^{-6} V

B 5.3×10^{-4} V

C 1.2×10^{-3} V

D 7.5×10^{5} V

24 The primary coil of a step-up transformer is connected to a source of alternating pd. The secondary coil is connected to a lamp.



Which line, **A** to **D**, in the table correctly describes the ratios of flux linkages and currents through the secondary coil in relation to the primary coil?

	Secondary magnetic flux linkage / Primary magnetic flux linkage	**Secondary current / Primary current**
A	< 1	< 1
B	> 1	< 1
C	> 1	> 1
D	< 1	> 1

25 Which one of the following statements is the main reason for operating power lines at high voltage?

A Transformers are never perfectly efficient.

B High voltages are required by many industrial users of electricity.

C Electrical generators produce alternating current.

D For a given amount of transmitted power, increasing the voltage decreases the current.

END OF QUESTIONS

There are no questions printed on this page

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AQA

Please write clearly in block capitals.

Centre number | | | | | |

Candidate number | | | | |

Surname ____________________

Forename(s) ____________________

Candidate signature ____________________

A-level
PHYSICS A

Unit 4 Fields and Further Mechanics
Section B

Monday 20 June 2016 Morning

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.

Materials

For this paper you must have:

- a calculator
- a ruler
- a Data and Formulae Booklet (enclosed).

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.

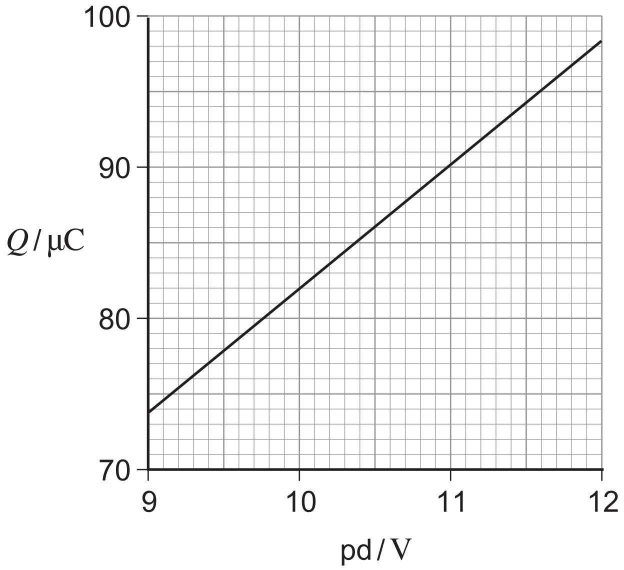
Section B

Answer **all** questions.

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

1 (a) **Figure 1** shows how the charge Q stored by a capacitor varies with the potential difference (pd) V across it as V is increased from 9.0 V to 12.0 V.

Figure 1



1 (a) (i) Use **Figure 1** to determine an accurate value for the capacitance of the capacitor.

[2 marks]

capacitance = ____________________________ μF

1 (a) (ii) Calculate the additional energy stored by the capacitor when V is increased from 9.0 V to 12.0 V.

[3 marks]

additional energy = ______________________________ J

Do not write outside the box

1 (b) When a $470\ \mu F$ capacitor is discharged through a fixed resistor R, the pd across it decreases by 80% in $45\ s$.

1 (b) (i) Calculate the time constant of the capacitor–resistor circuit.

[3 marks]

time constant = ____________________________ s

1 (b) (ii) Determine the resistance of R.

[2 marks]

resistance = ____________________________ Ω

1 (b) (iii) At which point during the discharging process is the capacitor losing charge at the smallest rate? Tick (✓) the correct answer.

[1 mark]

	✓ if correct
when the charge on the capacitor is greatest	
when energy is dissipated at the greatest rate	
when the current in the resistor is greatest	
when the pd across R is least	

11

Turn over ▶

2 The planet Venus may be considered to be a sphere of uniform density 5.24×10^3 kg m^{-3}.
The gravitational field strength at the surface of Venus is 8.87 N kg^{-1}.

2 (a) (i) Show that the gravitational field strength g_s at the surface of a planet is related to the the density ρ and the radius R of the planet by the expression

$$g_s = \frac{4}{3}\pi G R \rho$$

where G is the gravitational constant.

[2 marks]

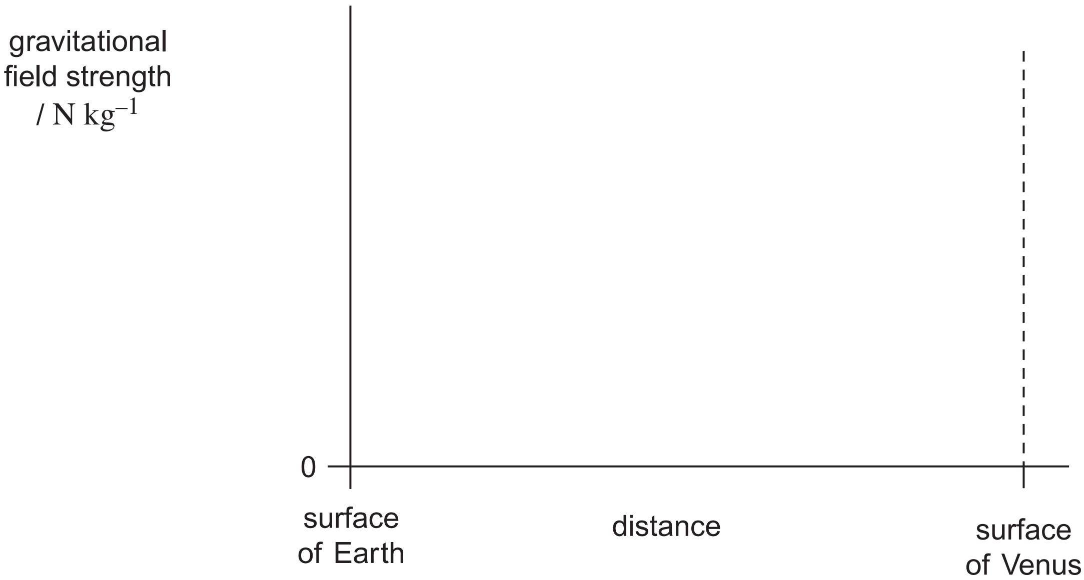
2 (a) (ii) Calculate the radius of Venus.
Give your answer to an appropriate number of significant figures.

[3 marks]

radius = ____________________________ m

2 (b) At a certain time, the positions of Earth and Venus are aligned so that the distance between them is a minimum.
Sketch a graph on the axes below to show how the magnitude of the gravitational field strength g varies with distance along the shortest straight line between their surfaces.
Consider only the contributions to the field produced by Earth and Venus.
Mark values on the vertical axis of your graph.

[3 marks]



8

Turn over for the next question

3 (a) State the condition for momentum to be conserved in a system.

[1 mark]

____

____

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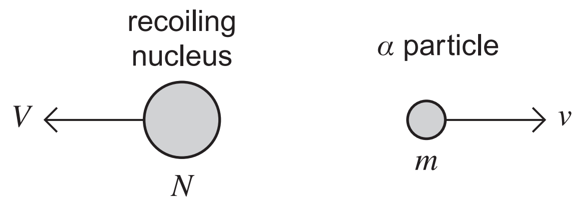
3 (b) When a stationary unstable nucleus emits an α particle with velocity v the resulting nucleus recoils with velocity V, as shown in **Figure 2**.

Figure 2



The mass of the α particle is m and the mass of the recoiling nucleus is N.

3 (b) (i) Show how the principle of conservation of momentum may be used to derive an expression for V in terms of N, m and v.

[2 marks]

Do not write outside the box

3 (b) (ii) Assume that all of the energy released in the emission process is transferred as kinetic energy to the α particle and the recoiling nucleus. The total energy released is E.
Use your result from part **(b)(i)** to show that the kinetic energy of the α particle is given by

$$E_\alpha = \left(\frac{N}{N + m}\right)E$$

[4 marks]

3 (c) (i) The isotope of radon $^{220}_{86}\mathrm{Rn}$ decays by emitting an α particle.

State the nucleon number of the recoiling nucleus.

[1 mark]

nucleon number = ______________________

Question 3 continues on the next page

Turn over ▶

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3 (c) (ii) The total energy released when a nucleus of $^{220}_{86}\text{Rn}$ decays is 1.02×10^{-12} J.

Calculate the magnitude of the momentum of the α particle.
State an appropriate unit for your answer.

Mass of a nucleon = 1.66×10^{-27} kg

[4 marks]

momentum = ____________ unit ____________

3 (d) Explain why the expressions in parts **(b)(i)** and **(b)(ii)** could **not** be applied when an unstable nucleus decays by emitting a β^- particle.

[1 mark]

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13

Turn over for the next question

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ANSWER IN THE SPACES PROVIDED

Do not write outside the box

4 Within certain limits, the bob of a simple pendulum of length l may be considered to move with simple harmonic motion of period T, where

$$T = 2\pi\sqrt{\frac{l}{g}}$$

4 (a) State **one** limitation that applies to the pendulum when this equation is used.

[1 mark]

4 (b) Describe an experiment to determine the value of the Earth's gravitational field strength g using a simple pendulum and any other appropriate apparatus.

In your answer you should:
- describe how you would arrange the apparatus
- indicate how you would make the measurements
- explain how you would calculate the value of g by a graphical method
- state the experimental procedures you would use to ensure that your result was accurate.

You may draw a diagram to help you with your answer.

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

[6 marks]

Question 4 continues on the next page

Turn over ▶

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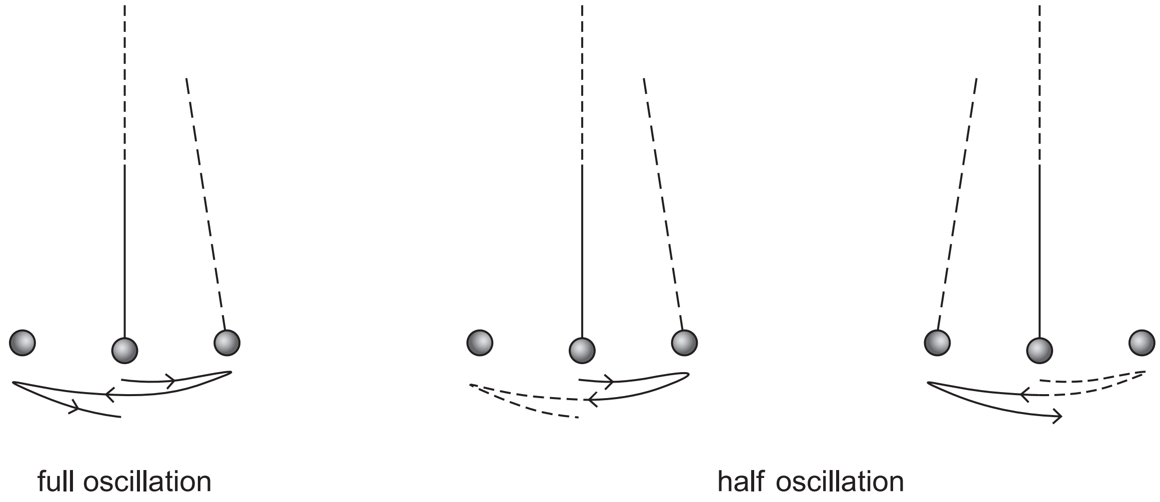
4 (c) When carrying out the experiment in part **(b)**, a student measures the time period incorrectly. Mistakenly, the student thinks that the time period is the time taken for half of an oscillation instead of a full oscillation, as illustrated in **Figure 3**.

Figure 3



Deduce the effect this will have on the value of g obtained from the experiment, explaining how you arrive at your answer.

[3 marks]

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10

Turn over for the next question

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5 (a) State, in words, the two laws of electromagnetic induction.

[3 marks]

Law 1 ____

____

____

____

Law 2 ____

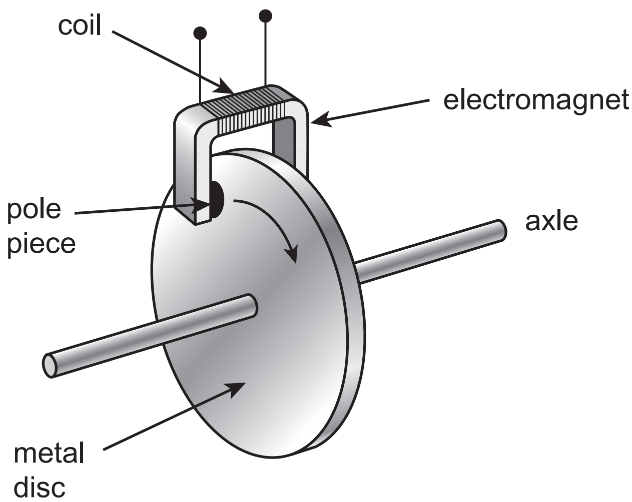
____

____

____

5 (b) **Figure 4** illustrates the main components of one type of electromagnetic braking system. A metal disc is attached to the rotating axle of a vehicle. An electromagnet is mounted with its pole pieces placed either side of the rotating disc, but not touching it. When the brakes are applied, a direct current is passed through the coil of the electromagnet and the disc slows down.

Figure 4



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5 (b) (i) Explain, using the laws of electromagnetic induction, how the device in **Figure 4** acts as an electromagnetic brake.

[3 marks]

5 (b) (ii) A conventional braking system has friction pads that are brought into contact with a moving metal surface when the vehicle is to be slowed down.
State **one** advantage and **one** disadvantage of an electromagnetic brake compared to a conventional brake.

[2 marks]

Advantage

Disadvantage

8

END OF QUESTIONS

There are no questions printed on this page

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