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

Thursday 15 June 2017 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 A ball of mass $0.40\ \text{kg}$ falls vertically to the floor. It strikes the floor at a speed of $5.9\ \text{m s}^{-1}$ and then rebounds vertically at a speed of $4.9\ \text{m s}^{-1}$.

What is the magnitude of the change of momentum of the ball during its collision with the floor?

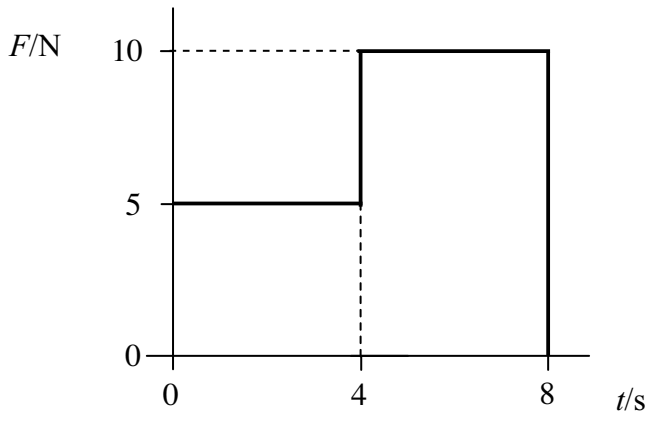
A $0.44\ \text{N s}$

B $1.2\ \text{N s}$

C $4.3\ \text{N s}$

D $4.7\ \text{N s}$

2 An object which is initially at rest is acted on by a force F which varies with time t as shown by the graph.



What is the momentum of the object after $8.0\ \text{s}$?

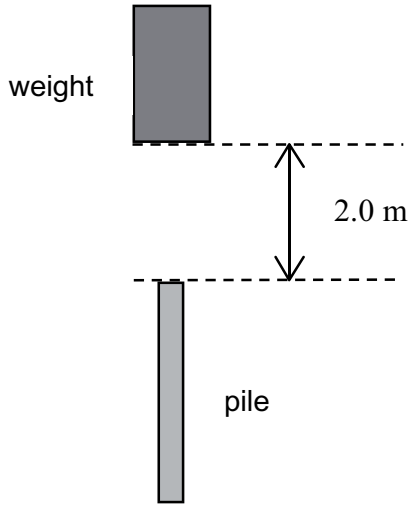
A $20\ \text{kg m s}^{-1}$

B $40\ \text{kg m s}^{-1}$

C $60\ \text{kg m s}^{-1}$

D $80\ \text{kg m s}^{-1}$

3 A pile driver drops a weight of $4900\ \text{N}$ through a vertical distance of $2.0\ \text{m}$ onto a stationary pile of mass $1500\ \text{kg}$.



The weight does not rebound.

What is the best estimate of the downward speed of the combined masses immediately after the impact?

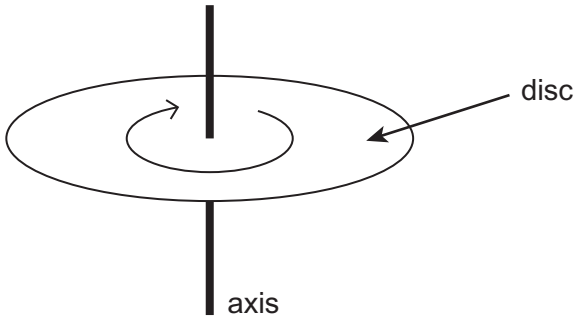
A $1.6\ \text{m s}^{-1}$

B $2.1\ \text{m s}^{-1}$

C $9.8\ \text{m s}^{-1}$

D $15\ \text{m s}^{-1}$

4 The diagram shows a disc of diameter $120\ \text{mm}$ that can turn about an axis through its centre.



The disc is turned through an angle of 30^{o} in a time of $20\ \text{ms}$.

What is the average speed of a point on the edge of the disc during this time?

A $0.5\pi\ \text{m s}^{-1}$

B $\pi\ \text{m s}^{-1}$

C $1.5\pi\ \text{m s}^{-1}$

D $2\pi\ \text{m s}^{-1}$

5 A mass on the end of a string is whirled round in a horizontal circle at increasing speed until the string breaks. The subsequent path taken by the mass is

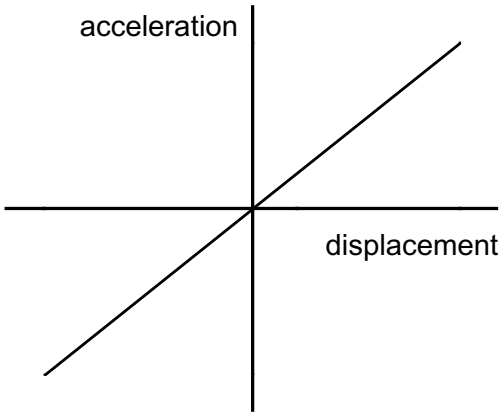
A a straight line along a radius of the circle.

B a horizontal circle.

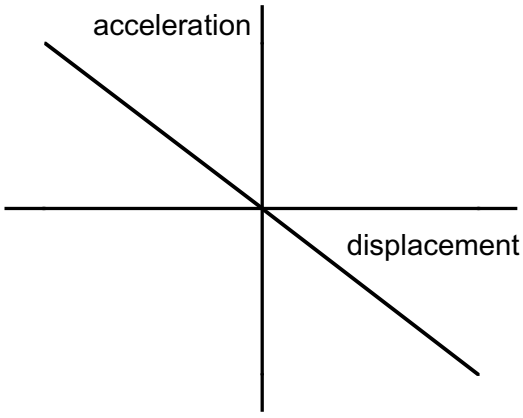
C a parabola in a horizontal plane.

D a parabola in a vertical plane.

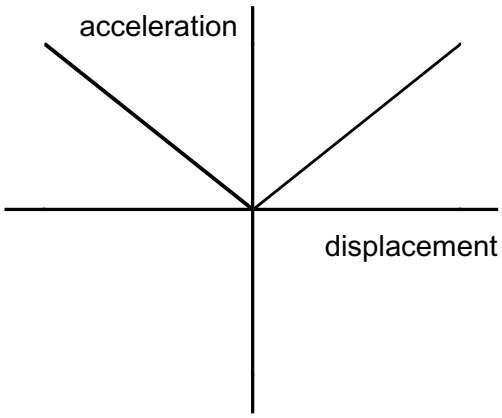
6 Which graph best shows the variation in acceleration with displacement for an object performing simple harmonic motion?



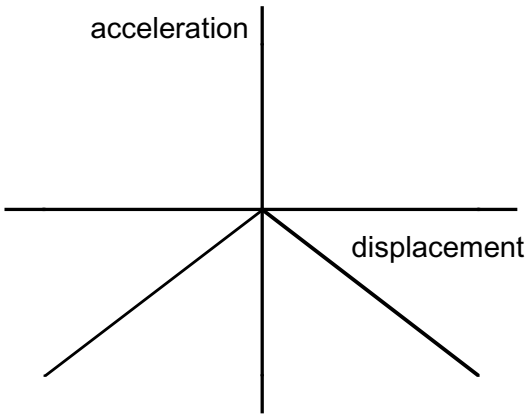
A



B

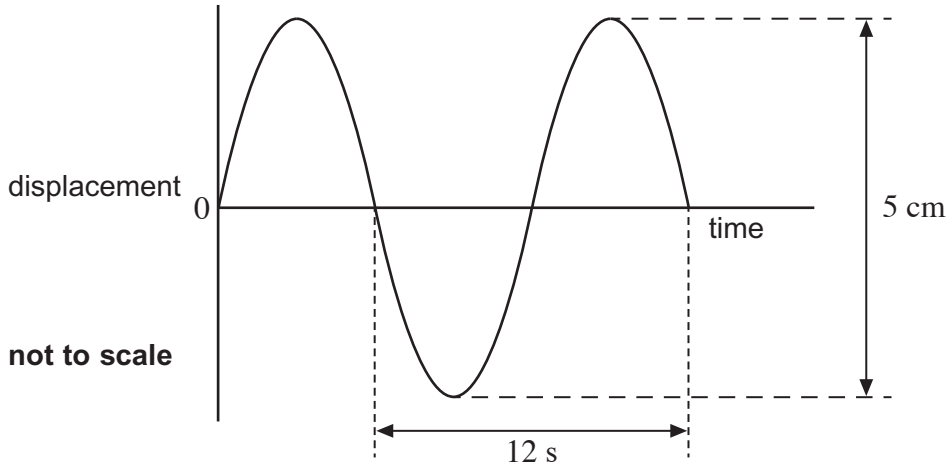


C



D

7 The graph shows how the displacement varies with time for a body performing simple harmonic motion.



What is the maximum speed of the body?

A $0.013\ \text{m s}^{-1}$

B $0.016\ \text{m s}^{-1}$

C $0.021\ \text{m s}^{-1}$

D $0.032\ \text{m s}^{-1}$

8 A lightly damped system is forced to vibrate at its natural frequency.

Which statement is **incorrect**?

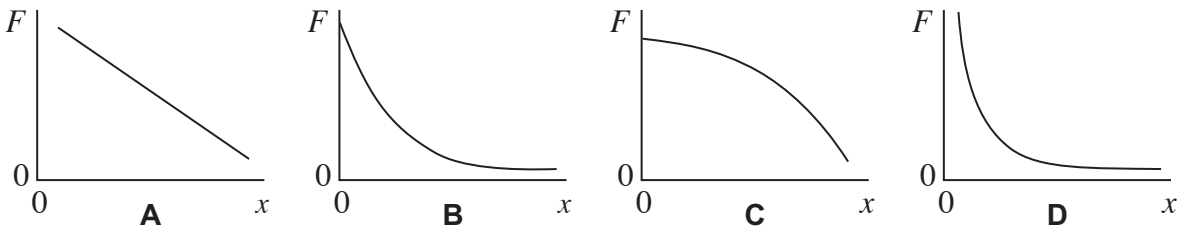
A The amplitude of vibration of the driven system is larger than at other frequencies.

B Energy is transferred from the driving system to the driven system.

C The driver system's displacement is in phase with the driven system's displacement.

D Resonance occurs.

9 Which graph best shows how the gravitational force F between two point masses varies with the separation x of the masses?



10 The radius of a planet is x times the radius of the Earth. The gravitational field strength at its surface is y times that at the surface of the Earth.

What is the ratio $\left(\frac{\text{mass of the planet}}{\text{mass of the Earth}} \right)$?

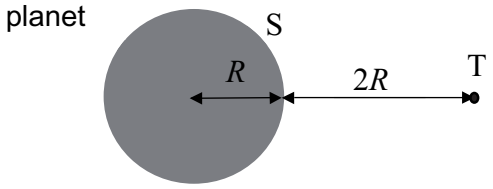
A xy

B x^2y

C xy^2

D x^2y^2

11 The gravitational potential at the surface S of a planet of radius R is V. Point T is a distance $2R$ away from the surface.



A spacecraft of mass m travels **from** T **to** S.

What is the change in its gravitational potential energy?

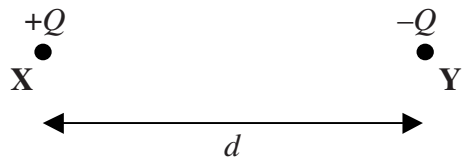
A It increases by $\frac{mV}{3}$.

B It decreases by $\frac{mV}{3}$.

C It increases by $\frac{2mV}{3}$.

D It decreases by $\frac{2mV}{3}$.

12 Two small charged objects **X** and **Y** have charges of $+Q$ and $-Q$ respectively. When they are at a separation d, the force between them is F.



A charge of $+2Q$ is added to each point charge and their separation is increased to $2d$.

Which line, **A** to **D**, in the table gives the magnitude and direction of the force on **X**?

	magnitude	direction
A	$\frac{F}{4}$	towards **Y**
B	$\frac{3F}{4}$	towards **Y**
C	$\frac{F}{4}$	away from **Y**
D	$\frac{3F}{4}$	away from **Y**

13 Which one of the following statements is correct?

The electrical potential V at a point **O** due to a negative charge at **X**

A is directly proportional to the distance between **O** and **X**.

B can be measured in J C^{-1}.

C is independent of the magnitude of the charge placed at **X**.

D is a vector quantity.

Turn over for the next question

14 The relationship between two physical quantities may be inverse, inverse square or exponential.

Which line, **A** to **D**, in the table shows correct relationships for

(i) pd and time in capacitor discharge
(ii) electric field strength and distance in a radial field
(iii) gravitational potential and distance in a radial field?

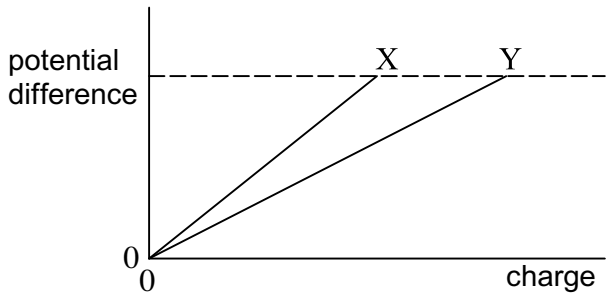
	(i) capacitor discharge	**(ii) electric field strength**	**(iii) gravitational potential**
A	exponential	inverse	inverse square
B	inverse	inverse square	exponential
C	inverse square	exponential	inverse
D	exponential	inverse square	inverse

15 A capacitor is charged until the potential difference (pd) across it is 12 V. When an additional charge of 36 μC is added, the pd increases to 30 V.

Which line, **A** to **D**, in the table gives correct values for the capacitance of the capacitor and for the charge it stored initially?

	capacitance/μF	**initial charge/μC**
A	0.5	24
B	2.0	24
C	0.5	36
D	2.0	36

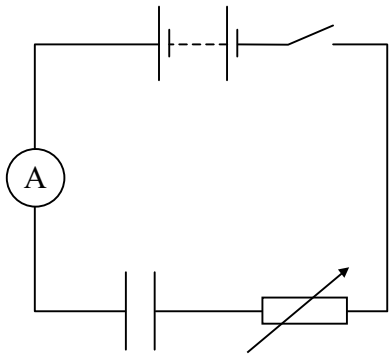
16 The graph shows how the potential differences across capacitors X and Y vary with the charge stored.



Which line, **A** to **D**, in the table shows correct relationships for the capacitances of X and Y and for the energy they store when at the same potential difference?

	capacitance	**energy stored**
A	X > Y	X > Y
B	X < Y	X > Y
C	X > Y	X < Y
D	X < Y	X < Y

17 A capacitor in series with an ammeter is charged through a variable resistor. The capacitor is initially uncharged.



The switch is closed and the variable resistor is continually adjusted to maintain a constant current I for time t. At the end of this time, the pd across the capacitor is V.

What is the energy stored in the capacitor at time t?

A $\frac{IVt}{4}$

B $\frac{IVt}{2}$

C IVt

D $2IVt$

18 A capacitor with an initial charge of $0.22\ \text{mC}$ is discharged through a resistor. The charge falls to $0.10\ \text{mC}$ in $10\ \text{s}$.

What is the time constant for the circuit?

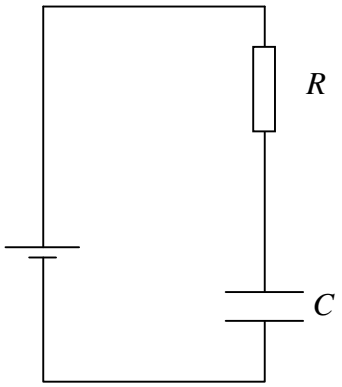
A $9\ \text{s}$

B $10\ \text{s}$

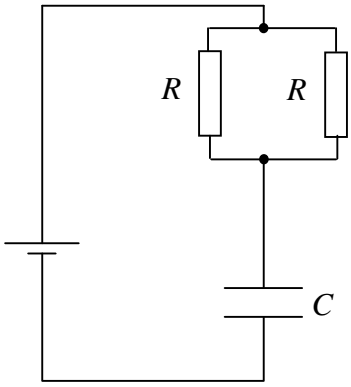
C $13\ \text{s}$

D $15\ \text{s}$

19 The time constant for circuit X is T.



circuit X



circuit Y

What is the time constant for circuit Y?

A $\frac{T}{2}$

B T

C $2T$

D $4T$

Turn over for the next question

20 An electron moving with a constant speed enters a uniform magnetic field in a direction perpendicular to the magnetic field.

What is the shape of the path that the electron follows?

A parabolic

B circular

C elliptical

D a line parallel to the magnetic field

21 An electron moves due north in a horizontal plane with uniform speed. It enters a uniform magnetic field directed due south in the same plane.

Which one of the following statements concerning the motion of the electron in the magnetic field is correct?

A It is accelerated due west.

B It slows down to zero speed and then accelerates due south.

C It continues to move north with its original speed.

D It is accelerated due north.

22 A proton in a uniform magnetic field of flux density B moves in a circle of radius r at speed v.

What would be the flux density of the field that would keep an α particle moving in a circle of the same radius at the same speed?

A $\frac{B}{2}$

B B

C $2B$

D $4B$

23 The table shows data for four different rectangular coils.

coil	length of longest side/m	length of shortest side/m	number of turns
W	0.05	0.05	2
X	0.10	0.08	20
Y	0.15	0.10	15
Z	0.20	0.12	5

The coils are placed in a uniform magnetic field which acts at right angles to the plane of the coils.

Which one of the following shows the coils arranged in order of greatest to least flux linkage?

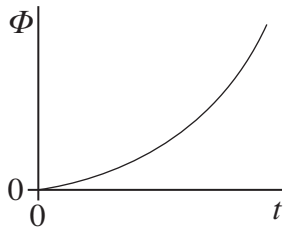
A YXZW

B XYZW

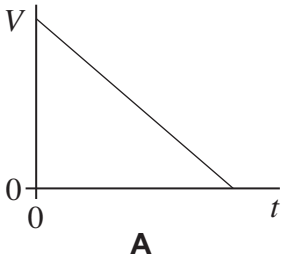
C ZYXW

D WXYZ

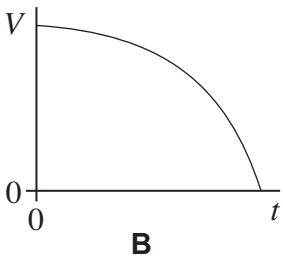
24 The graph shows how the magnetic flux Φ passing through a coil changes with time t.



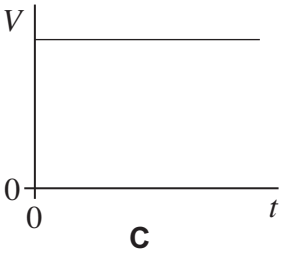
Which graph best shows how the magnitude of the emf V induced in the coil varies with t?



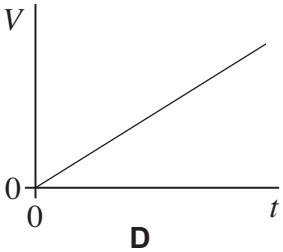
A



B

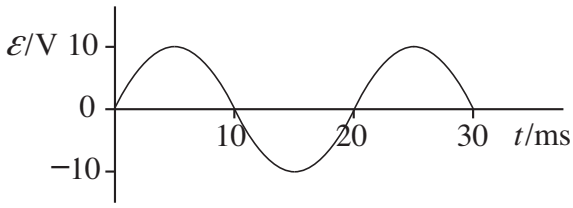


C



D

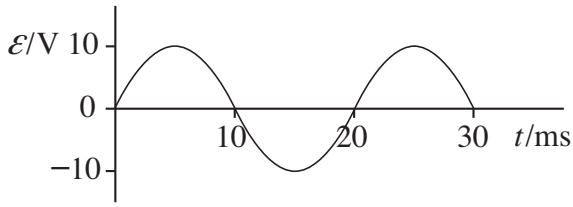
25 The graph shows how the output emf $\mathcal{E}$ varies with time t for a coil rotating at angular speed ω in a uniform magnetic field of flux density B.



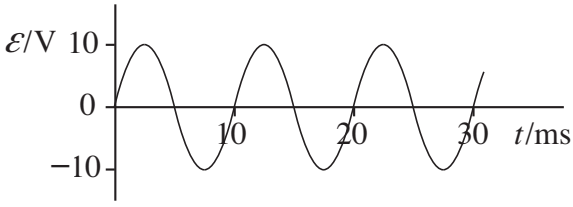
The same coil is rotated at angular speed 2ω in a uniform magnetic field of flux density $0.5B$.

Which graph best shows how $\mathcal{E}$ varies with t?

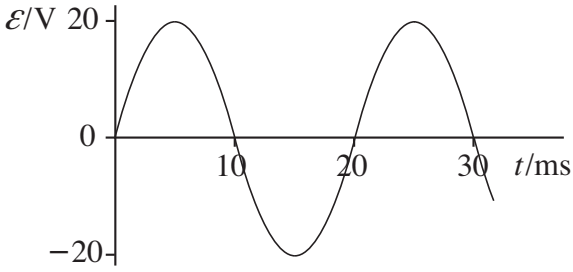
A



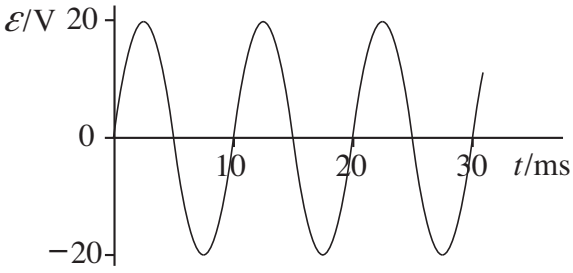
B



C



D



END OF SECTION A

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

Thursday 15 June 2017 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 pencil and 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.

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
TOTAL	

Section B

Answer **all** questions.

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

1 (a) Describe the energy changes that take place as the bob of a simple pendulum makes one complete oscillation. Start your answer at the point where the bob has zero acceleration.

[2 marks]

1 (b)

Figure 1

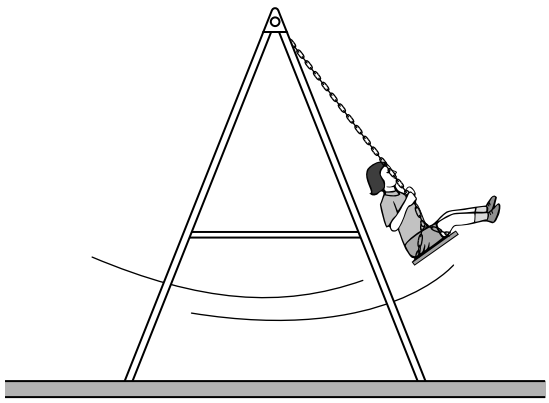


Figure 1 shows a girl on a swing that completes 20 oscillations in a time of 64 s. Assume that the swing behaves as a simple pendulum. Ignore the mass of the chains supporting the seat throughout this question.

1 (b) (i) Calculate the distance from the top of the chains to the centre of mass of the girl and seat. Give your answer to an appropriate number of significant figures.

[4 marks]

distance = _____ m

1 (b) (ii) The girl is displaced from the lowest point and released from rest. This initial displacement raises the centre of mass of the girl by 280 mm above its lowest point. The mass of the girl is 21 kg.

Calculate her kinetic energy as she first passes through this lowest point.

[2 marks]

kinetic energy = _____ J

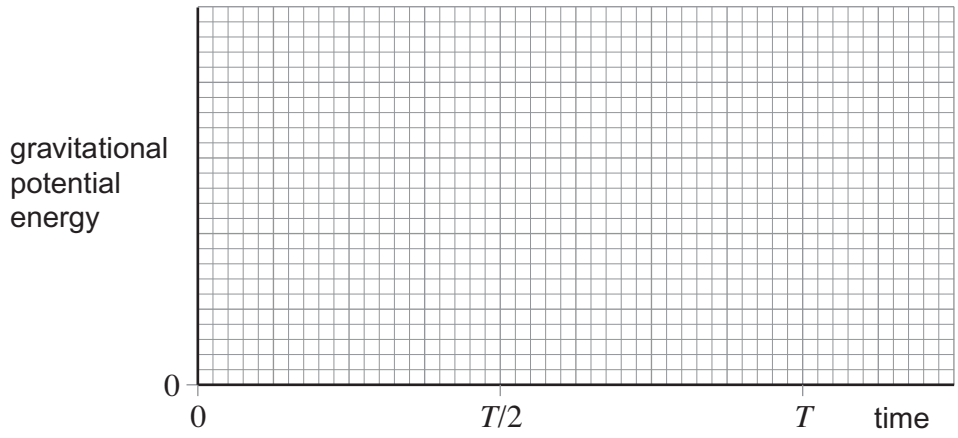
1 (b) (iii) Calculate the maximum speed of the girl.

[1 mark]

maximum speed = _____ $m\ s^{-1}$

1 (c)

Figure 2



Draw a graph on **Figure 2** to show how the gravitational potential energy of the girl varies with time during the first complete oscillation. Start your graph at the time of her release from maximum displacement. On the time axis of the graph, T represents the period of the swing. You do not need to show any values on the vertical axis.

[3 marks]

12

2 (a) A communications satellite is in orbit around the Earth. The satellite is in continuous line-of-sight contact with a ground station.

Which of the following statements about the satellite is/are correct?
Place a tick (✓) in the right-hand column alongside **each** correct statement.

[1 mark]

Statement	Tick (✓) if correct
It is in a polar orbit.	
It maintains a fixed position relative to the Earth's surface.	
It remains in a fixed position in space.	
Its rotational period equals the orbital period of the Earth.	
Its orbital period equals the rotational period of the Earth.	

2 (b) A satellite of mass m travels at angular speed ω in a circular orbit at a height h above the surface of a planet of mass M and radius R.

2 (b) (i) Give an equation that relates the gravitational force on the satellite to the centripetal force. Use the symbols m, ω, h, M and R, and any additional standard symbols.

[1 mark]

2 (b) (ii) Use your equation from part **(b) (i)** to show that the orbital period T of the satellite is given by

$$T^2 = \frac{4\pi^2 (R + h)^3}{GM}$$

[2 marks]

Question 2 continues on the next page

2 (b) (iii) Explain why the period of a satellite in orbit around the Earth cannot be less than 85 minutes. Your answer should include a calculation to justify this value.

mass of the Earth $= 6.00 \times 10^{24}$ kg
radius of the Earth $= 6.40 \times 10^{6}$ m

[3 marks]

2 (c) Describe and explain what happens to the speed of a satellite when it moves from one orbit to another orbit that is closer to the Earth.

[2 marks]

9

3 (a) An α particle enters a uniform electric field that is directed at right angles to the velocity of the α particle.

3 (a) (i) State the direction of the electric force that acts on the α particle.

[1 mark]

3 (a) (ii) Describe and explain the subsequent motion of the α particle.

[2 marks]

3 (b) An α particle enters a uniform electric field whose direction is the same as that of the velocity of the α particle.

3 (b) (i) State the direction of the electric force that acts on the α particle.

[1 mark]

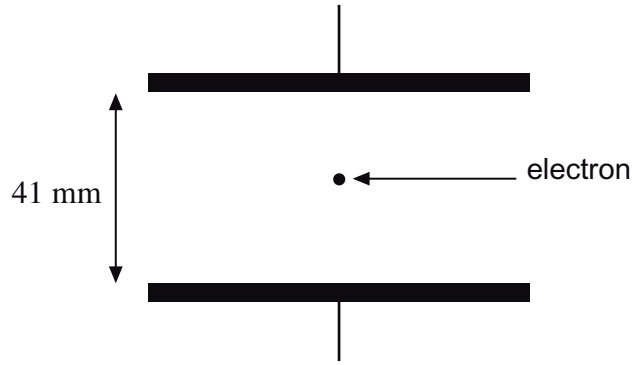
3 (b) (ii) Describe and explain the subsequent motion of the α particle.

[1 mark]

Question 3 continues on the next page

3 (c) **Figure 3** shows two parallel metal plates with an electron between them. The plates are $41\ \text{mm}$ apart and have a potential difference (pd) of $130\ \text{V}$ applied across them.

Figure 3



3 (c) (i) Show that the electric field strength between the plates is about $3200\ \text{V m}^{-1}$.

[1 mark]

3 (c) (ii) Calculate the magnitude of the electric force on the electron when it is between the plates.

[1 mark]

magnitude of force = _____ N

3 (c) (iii) Calculate the kinetic energy, in J, that is gained by the electron when it starts from rest at one plate and crosses to the other plate.

[2 marks]

kinetic energy = _____ J

9

Turn over for the next question

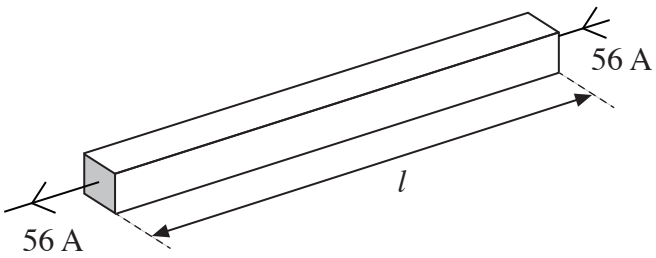
4 (a) The equation $F = BIl$ gives the magnetic force that acts on a conductor in a magnetic field.

State the condition under which the equation applies.

[1 mark]

4 (b) **Figure 4** shows a horizontal aluminium bar of $30\ \text{mm} \times 30\ \text{mm}$ square cross section and length l carrying a current of $56\ \text{A}$.

Figure 4



4 (b) (i) It is required to support the weight of the bar by the magnetic force that acts on it.

Calculate the minimum magnitude of the magnetic flux density of the magnetic field in which the bar should be placed for this to happen.

State an appropriate unit for your answer.

density of aluminium = 2.7×10^3 kg m^{-3}

[5 marks]

magnetic flux density = _____ unit _____

4 (b) (ii) Draw an arrow on **Figure 4** to show the direction in which the magnetic field should be applied for your calculation in part **(b) (i)** to be valid. Label your arrow **M**.

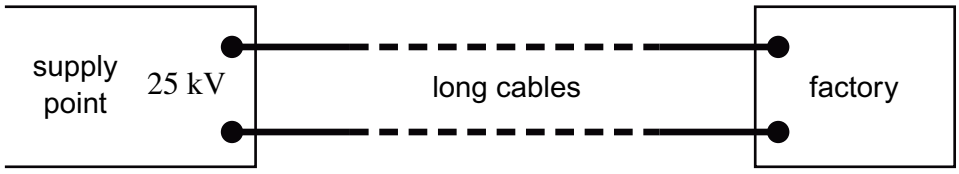
[1 mark]

7

Turn over for the next question

5 (a) Long cables are used to transmit electrical power from a supply point to a factory some distance away, as shown in **Figure 5**. An input power of 750 kW at 25 kV is supplied to the cables.

Figure 5



5 (a) (i) Calculate the current in each cable.

[1 mark]

current = _____ A

5 (a) (ii) The total resistance of the cables is 20 Ω.

Calculate the power supplied to the factory by the cables.

[2 marks]

power = _____ kW

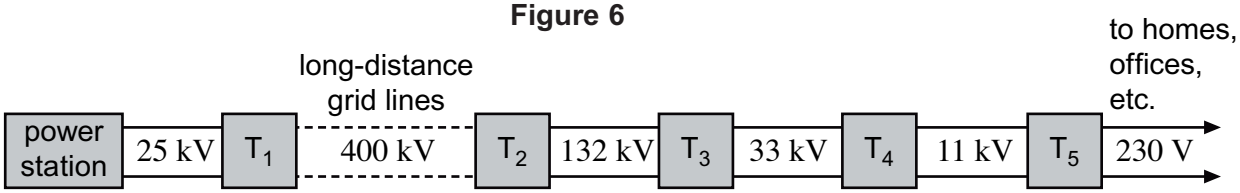
5 (a) (iii) Calculate the percentage efficiency with which power is transmitted by the cables from the input at the supply point to the factory.

[1 mark]

percentage efficiency = _____ %

5 (b) In Britain, most electrical generators at power stations provide an output at 25 kV. Most homes, offices and shops are supplied with electricity at 230 V.
Figure 6 shows the main principles of the grid system, by which power is transmitted from a power station to the consumers. In this network, T_1, T_2, T_3, T_4 and T_5 are transformers.

Figure 6



5 (b) (i) Explain how a step-up transformer differs in construction from a step-down transformer.
[1 mark]

5 (b) (ii) Explain why the primary windings of a step-up transformer should be made from thicker copper wire than the secondary windings.
[2 marks]

Question 5 continues on the next page

5 (c) Discuss the principles involved in the high-voltage systems used for the transmission of electrical energy, as illustrated in **Figure 6**.
In your answer you should explain

- how energy losses are minimised
- why alternating current (ac) is preferred to direct current (dc)
- why the reduction in voltage is usually carried out in several stages.

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

[6 marks]

END OF QUESTIONS

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