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**

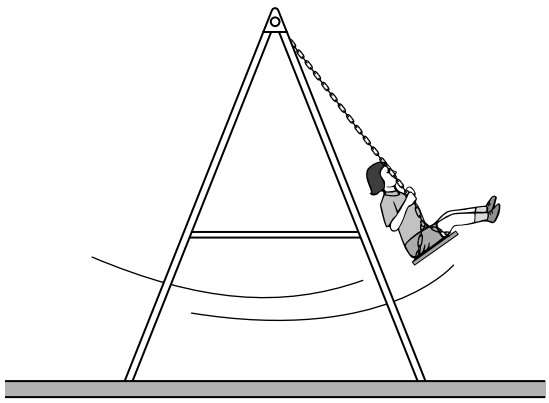


**Figure 1** shows a girl on a swing that completes $20$ oscillations in a time of $64$ s. Assume that the swing behaves as a simple pendulum. Ignore the mass of the chains supporting the seat throughout this question.

**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

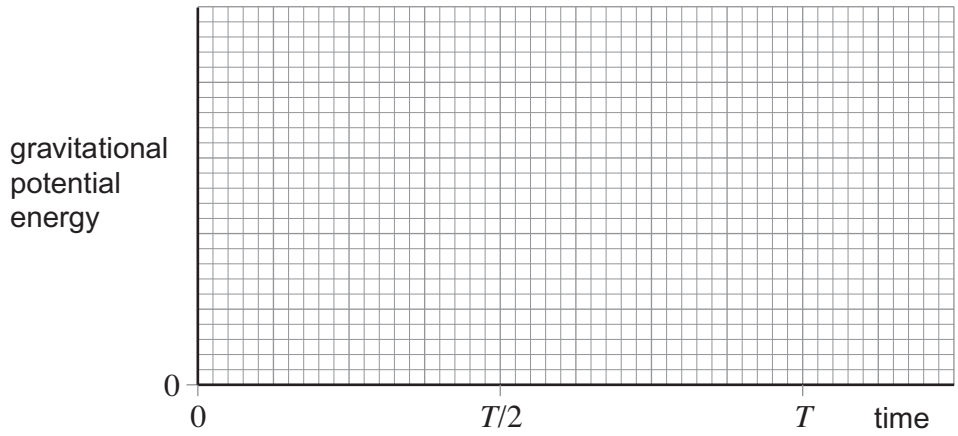
**1 (b) (iii)** Calculate the maximum speed of the girl.

**[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 $\omega$ 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 $m$, $\omega$, $h$, $M$ 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 $\alpha$ particle enters a uniform electric field that is directed at right angles to the velocity of the $\alpha$ particle.

**3 (a) (i)** State the direction of the electric force that acts on the $\alpha$ particle.

**[1 mark]**

**3 (a) (ii)** Describe and explain the subsequent motion of the $\alpha$ particle.

**[2 marks]**

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

**3 (b) (i)** State the direction of the electric force that acts on the $\alpha$ particle.

**[1 mark]**

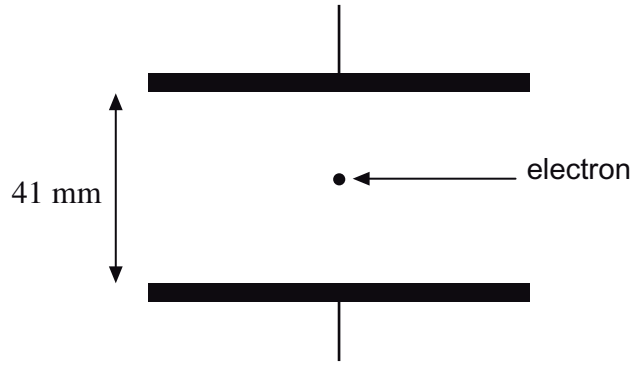
**3 (b) (ii)** Describe and explain the subsequent motion of the $\alpha$ particle.

**[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**

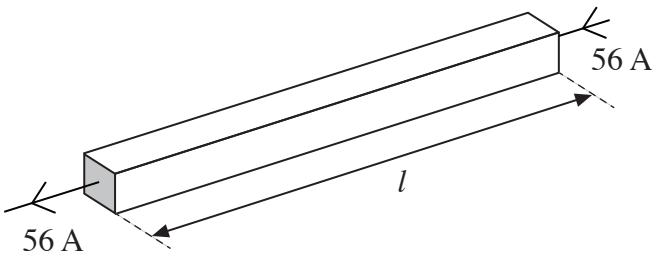
**4 (a)** The equation $F = BIl$ gives the magnetic force that acts on a conductor in a magnetic field.

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 = $2.7 \times 10^3$ 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**.

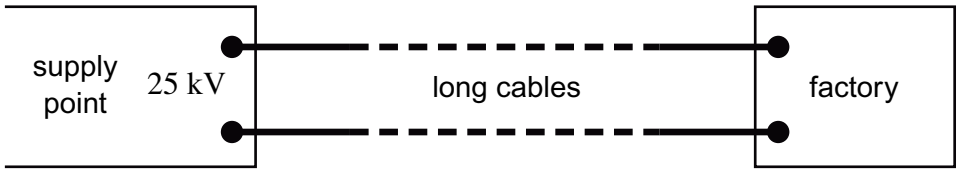
**[1 mark]**

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

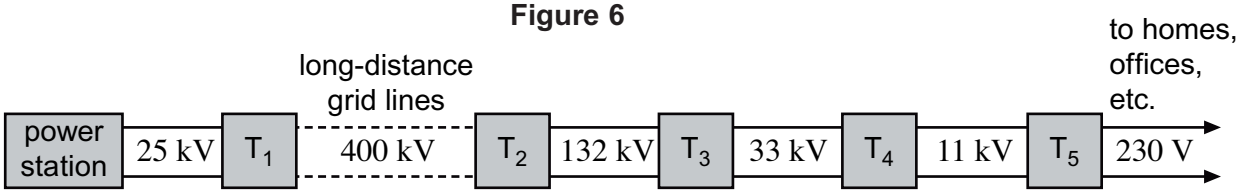
**5 (a) (iii)** Calculate the percentage efficiency with which power is transmitted by the cables from the input at the supply point to the factory.

**[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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**There are no questions printed on this page**

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**ANSWER IN THE SPACES PROVIDED**