Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

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

General Certificate of Education
Advanced Level Examination
January 2010

Physics A PHYA4/2

Unit 4 Fields and Further Mechanics
Section B

Thursday 28 January 2010 1.30 pm to 3.15 pm

For this paper you must have:
- a calculator
- a ruler
- 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 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 spaces 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.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this section 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.

Areas outside the box will not be scanned for marking

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, starting at its maximum displacement.

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(2 marks)

1 (b) **Figure 1**

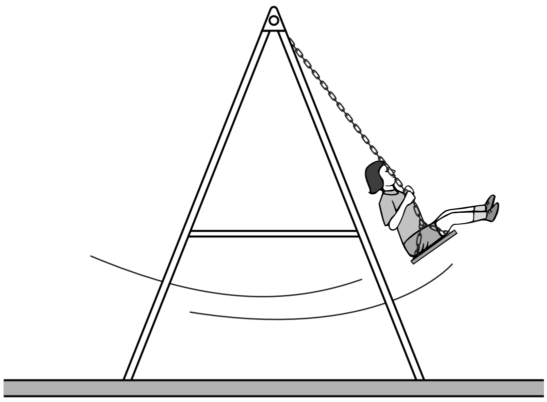


Figure 1 shows a young girl swinging on a garden swing. You may assume that the swing behaves as a simple pendulum. Ignore the mass of chains supporting the seat throughout this question, and assume that the effect of air resistance is negligible.
15 complete oscillations of the swing took 42s.

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

answer = ... m

(4 marks)

Areas outside the box will not be scanned for marking

1 (b) (ii) To set her swinging, the girl and seat were displaced from equilibrium and released from rest. This initial displacement of the girl raised the centre of mass of the girl and seat 250 mm above its lowest position. If the mass of the girl was 18 kg, what was her kinetic energy as she first passed through this lowest point?

answer = ... J

(2 marks)

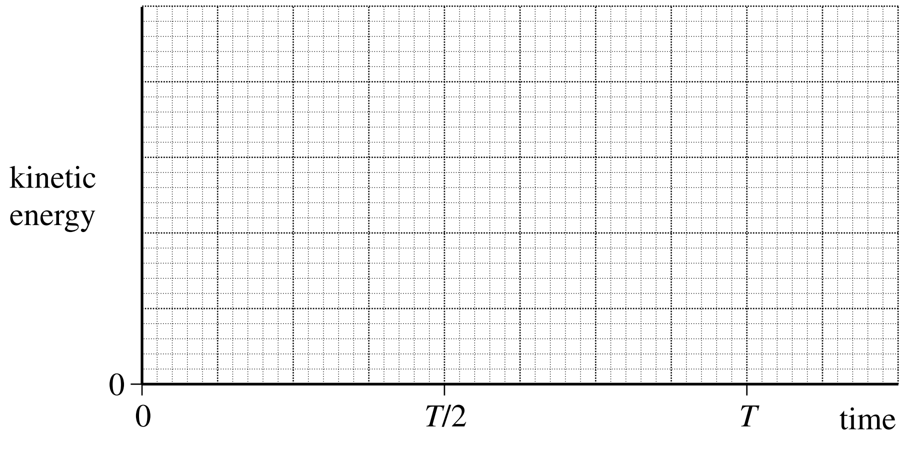
1 (b) (iii) Calculate the maximum speed of the girl during the first oscillation.

answer = ... m s^{-1}

(1 mark)

1 (c)

Figure 2



On **Figure 2** draw a graph to show how the kinetic energy of the girl varied with time during the first complete oscillation, starting at the time of her release from maximum displacement. On the horizontal 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

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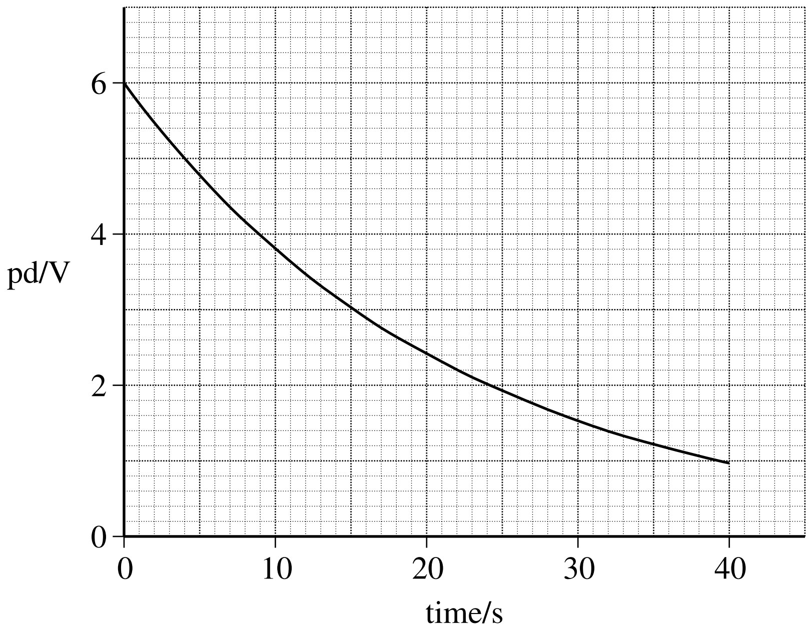
2 (a) A capacitor, initially charged to a pd of 6.0 V, was discharged through a 100 kΩ resistor. A datalogger was used to record the pd across the capacitor at frequent intervals. The graph shows how the pd varied with time during the first 40 s of discharge.



2 (a) (i) Calculate the initial discharge current.

answer = ... A

(1 mark)

2 (a) (ii) Use the graph to determine the time constant of the circuit, giving an appropriate unit.

answer = ...

(4 marks)

Areas outside the box will not be scanned for marking

2 (a) (iii) Hence calculate the capacitance of the capacitor.

answer = ... μF
(1 mark)

2 (a) (iv) Show that the capacitor lost 90% of the energy it stored originally after about 25 s.

(3 marks)

2 (b) In order to produce a time delay, an intruder alarm contains a capacitor identical to the capacitor used in the experiment in part (a). This capacitor is charged from a 12 V supply and then discharges through a 100 kΩ resistor, similar to the one used in the experiment.

2 (b) (i) State and explain the effect of this higher initial pd on the energy stored by this capacitor initially.

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(2 marks)

2 (b) (ii) State and explain the effect of this higher initial pd on the time taken for this capacitor to lose 90% of its original energy.

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(1 mark)

12

Turn over ▶

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3 (a) (i) State the relationship between the *gravitational potential energy*, E_p, and the *gravitational potential*, V, for a body of mass m placed in a gravitational field.

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(1 mark)

3 (a) (ii) What is the effect, if any, on the values of E_p and V if the mass m is doubled?

value of E_p ....

value of V ....

(2 marks)

3 (b)

Figure 3

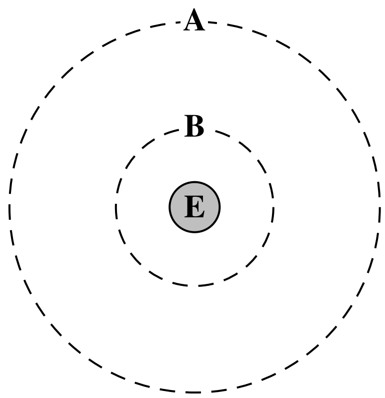

Figure 3 shows two of the orbits, **A** and **B**, that could be occupied by a satellite in circular orbit around the Earth, **E**.
The gravitational potential due to the Earth of each of these orbits is:

orbit **A**	$-12.0\ \text{MJ kg}^{-1}$
orbit **B**	$-36.0\ \text{MJ kg}^{-1}$.

3 (b) (i) Calculate the radius, from the centre of the Earth, of orbit **A**.

answer = ... m

(2 marks)

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3 (b) (ii) Show that the radius of orbit **B** is approximately 1.1×10^4 km.

(1 mark)

3 (b) (iii) Calculate the centripetal acceleration of a satellite in orbit **B**.

answer = ... $m\,s^{-2}$
(2 marks)

3 (b) (iv) Show that the gravitational potential energy of a 330 kg satellite decreases by about 8 GJ when it moves from orbit **A** to orbit **B**.

(1 mark)

3 (c) Explain why it is not possible to use the equation $\Delta E_p = mg\Delta h$ when determining the change in the gravitational potential energy of a satellite as it moves between these orbits.

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(1 mark)

10

Turn over ▶

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4 (a) (i) Outline the essential features of a step-down transformer when in operation.

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(2 marks)

4 (a) (ii) Describe **two** causes of the energy losses in a transformer and discuss how these energy losses may be reduced by suitable design and choice of materials.
The quality of your written communication will be assessed in this question.

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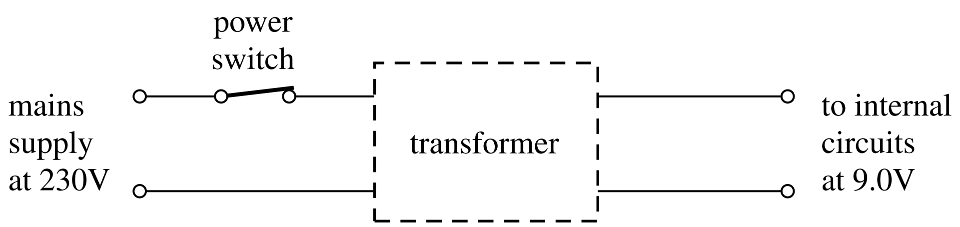
(6 marks)

4 (b) Electronic equipment, such as a TV set, may usually be left in 'standby' mode so that it is available for instant use when needed. Equipment left in standby mode continues to consume a small amount of power. The internal circuits operate at low voltage, supplied from a transformer. The transformer is disconnected from the mains supply only when the power switch on the equipment is turned off. This arrangement is outlined in **Figure 4**.

Figure 4



When in standby mode, the transformer supplies an output current of 300 mA at 9.0 V to the internal circuits of the TV set.

4 (b) (i) Calculate the power wasted in the internal circuits when the TV set is left in standby mode.

answer = ... W

(1 mark)

Question 4 continues on the next page

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4 (b) (ii) If the efficiency of the transformer is 0.90, show that the current supplied by the 230 V mains supply under these conditions is 13 mA.

(2 marks)

4 (b) (iii) The TV set is left in standby mode for 80% of the time. Calculate the amount of energy, in J, that is wasted in one year through the use of the standby mode.

$$1 \text{ year} = 3.15 \times 10^7 \text{ s}$$

answer = ... J

(1 mark)

4 (b) (iv) Show that the cost of this wasted energy will be about £4, if electrical energy is charged at 20 p per kWh.

(2 marks)

4 (c) The power consumption of an inactive desktop computer is typically double that of a TV set in standby mode. This waste of energy may be avoided by switching off the computer every time it is not in use. Discuss **one** advantage and **one** disadvantage of doing this.

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(2 marks)

END OF QUESTIONS

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