Centre Number						Candidate Number				
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Candidate Signature										

General Certificate of Education
Advanced Level Examination
January 2010

Physics A PHYA4/1

Unit 4 Fields and Further Mechanics
Section A

Thursday 28 January 2010 1.30 pm to 3.15 pm

In addition to this paper you will require:
- an objective test answer sheet
- a black ink or black ball-point pen
- a calculator
- a question paper/answer book for Section B (enclosed).

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 black ink or black ball-point pen. Do **not** use pencil.
- 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.

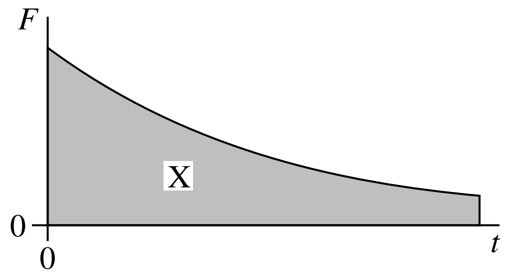
Information
- The maximum mark for this section is 25.
- Section A and Section B of this paper together carry 20% of the total marks for Physics Advanced.
- All questions in Section A carry equal marks. No deductions will be made for incorrect answers.
- A *Data and Formulae Booklet* is provided as a 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 approximately **45 minutes** on this section.

1 The graph shows the variation with time, t, of the force, F, acting on a body.



What physical quantity does the area X represent?

A the displacement of the body
B the acceleration of the body
C the change in momentum of the body
D the change in kinetic energy of the body

2 Water of density $1000\,\text{kg m}^{-3}$ flows out of a garden hose of cross-sectional area $7.2 \times 10^{-4}\,\text{m}^2$ at a rate of $2.0 \times 10^{-4}\,\text{m}^3$ per second. How much momentum is carried by the water leaving the hose per second?

A $5.6 \times 10^{-5}\,\text{N s}$
B $5.6 \times 10^{-2}\,\text{N s}$
C $0.20\,\text{N s}$
D $0.72\,\text{N s}$

3 Which row, **A** to **D**, in the table correctly shows the quantities conserved in an inelastic collision?

	mass	**momentum**	**kinetic energy**	**total energy**
A	conserved	not conserved	conserved	conserved
B	not conserved	conserved	conserved	not conserved
C	conserved	conserved	conserved	conserved
D	conserved	conserved	not conserved	conserved

4 What is the angular speed of a point on the Earth's equator?

A 7.3×10^{-5} rad s^{-1}
B 4.2×10^{-3} rad s^{-1}
C 2.6×10^{-1} rad s^{-1}
D 15 rad s^{-1}

5 Which one of the following does **not** involve a centripetal force?

A an electron in orbit around a nucleus
B a car going round a bend
C an α particle in a magnetic field, travelling at right angles to the field
D an α particle in a electric field, travelling at right angles to the field

6 Which one of the following gives the phase difference between the particle velocity and the particle displacement in simple harmonic motion?

A $\frac{\pi}{4}$ rad

B $\frac{\pi}{2}$ rad

C $\frac{3\pi}{4}$ rad

D 2π rad

7 A mass M hangs in equilibrium on a spring. M is made to oscillate about the equilibrium position by pulling it down 10 cm and releasing it. The time for M to travel back to the equilibrium position for the first time is 0.50 s. Which row, **A** to **D**, in the table is correct for these oscillations?

	amplitude / cm	**period / s**
A	10	1.0
B	10	2.0
C	20	2.0
D	20	1.0

8 Which one of the following statements concerning forced vibrations and resonance is correct?

A An oscillating body that is not resonating will return to its natural frequency when the forcing vibration is removed.
B At resonance, the displacement of the oscillating body is 180° out of phase with the forcing vibration.
C A pendulum with a dense bob is more heavily damped than one with a less dense bob of the same size.
D Resonance can only occur in mechanical systems.

9 Two identical spheres exert a gravitational force *F* on each other. What is the gravitational force between two spheres, each twice the mass of one of the original spheres, when the separation of their centres is twice the original separation?

A F
B $2F$
C $4F$
D $8F$

10 A planet of mass *M* and radius *R* rotates so rapidly that loose material at the equator only just remains on the surface. What is the period of rotation of the planet?

G is the universal gravitational constant.

A $2\pi\sqrt{\frac{R}{GM}}$

B $2\pi\sqrt{\frac{R^2}{GM}}$

C $2\pi\sqrt{\frac{GM}{R^3}}$

D $2\pi\sqrt{\frac{R^3}{GM}}$

11 The radius of a certain planet is x times the radius of the Earth and its surface gravitational field strength is y times that of the Earth.

Which one of the following gives 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

12 Which one of the following could be a unit of gravitational potential?

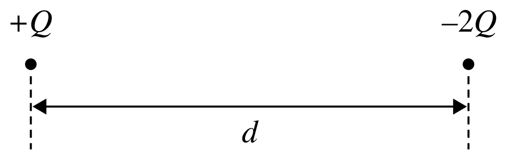
A N

B J

C $N\,kg^{-1}$

D $J\,kg^{-1}$

13



The diagram shows two particles at a distance d apart. One particle has charge $+Q$ and the other $-2Q$. The two particles exert an electrostatic force of attraction, F, on each other. Each particle is then given an additional charge $+Q$ and their separation is increased to a distance $2d$. Which one of the following gives the force that now acts between the two particles?

A an attractive force of $\frac{F}{4}$

B a repulsive force of $\frac{F}{4}$

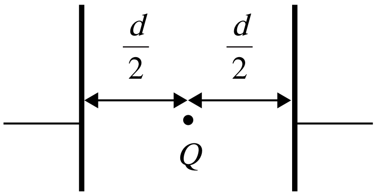
C an attractive force of $\frac{F}{2}$

D a repulsive force of $\frac{F}{2}$

14 Which one of the following statements about a charged particle in an electric field is correct?

A No work is done when a charged particle moves along a field line.
B No force acts on a charged particle when it moves along a field line.
C No work is done when a charged particle moves along a line of constant potential.
D No force acts on a charged particle when it moves along a line of constant potential.

15 Two parallel metal plates separated by a distance *d* have a potential difference *V* across them. What is the magnitude of the electrostatic force acting on a charge *Q* placed midway between the plates?



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

B $\frac{VQ}{d}$

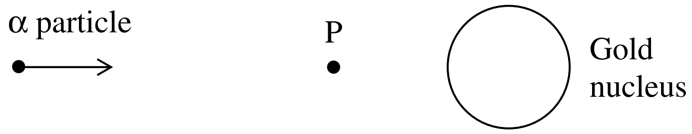
C $\frac{VQ}{2d}$

D $\frac{Qd}{V}$

16 Which one of the following statements about *electric field strength* and *electric potential* is **incorrect**?

A Electric potential is a scalar quantity.
B Electric field strength is a vector quantity.
C Electric potential is zero whenever the electric field strength is zero.
D The potential gradient is proportional to the electric field strength.

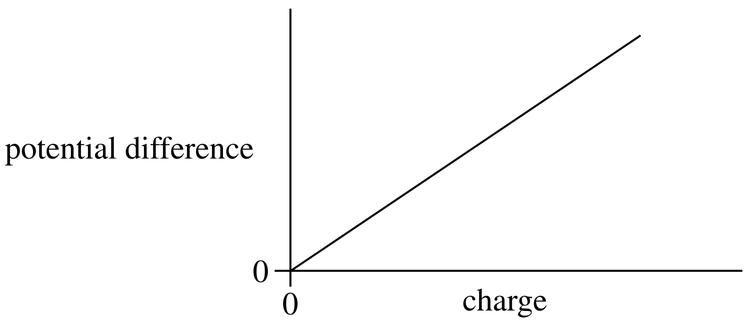
17



An α particle travels towards a gold nucleus and at P reverses its direction.
Which one of the following statements is **incorrect**?

A The electric potential energy of the α particle is a maximum at P.
B The kinetic energy of the α particle is a minimum at P.
C The total energy of the α particle is zero.
D The total energy of the α particle has a constant positive value.

18 The graph shows how the potential difference across a capacitor varies with the charge stored by it.



Which one of the following statements is correct?

A The gradient of the line equals the capacitance of the capacitor.
B The gradient of the line equals the energy stored by the capacitor.
C The reciprocal of the gradient equals the energy stored by the capacitor.
D The reciprocal of the gradient equals the capacitance of the capacitor.

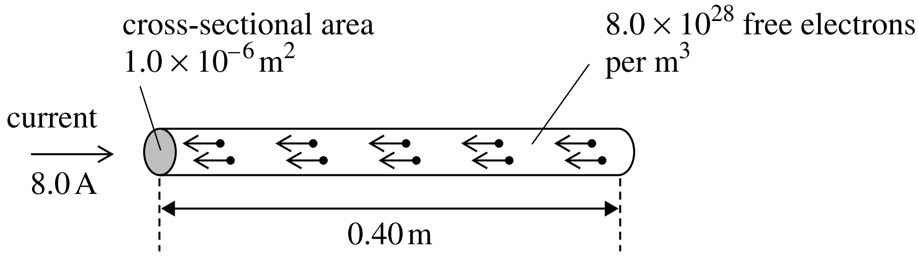
19 An initially uncharged capacitor of capacitance 10 μF is charged by a **constant** current of 200 μA. After what time will the potential difference across the capacitor be 2000 V?

A 50 s
B 100 s
C 200 s
D 400 s

20 A 1000 μF capacitor, X, and a 100 μF capacitor, Y, are charged to the same potential difference. Which row, **A** to **D**, in the table gives correct ratios of charge stored and energy stored by the capacitors?

	$\frac{\textbf{charge stored by X}}{\textbf{charge stored by Y}}$	$\frac{\textbf{energy stored by X}}{\textbf{energy stored by Y}}$
A	1	1
B	1	10
C	10	1
D	10	10

21



A current of 8.0 A is passed through a conductor of length 0.40 m and cross-sectional area 1.0×10^{-6} m^2. The conductor contains 8.0×10^{28} free electrons per m^3. When the conductor is at right angles to a magnetic field of flux density 0.20 T, it experiences a magnetic force. What is the average magnetic force that acts on **one** of the free electrons in the wire?

A 8.0×10^{-30} N

B 5.0×10^{-29} N

C 8.0×10^{-24} N

D 2.0×10^{-23} N

22 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 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.

23 Particles of mass m, each carrying charge Q and travelling with speed v, enter a magnetic field of flux density B at right angles. Which one of the following changes would produce an increase in the radius of the path of the particles?

A an increase in Q
B an increase in m
C a decrease in v
D an increase in B

24 The magnetic flux through a coil of N turns is increased uniformly from zero to a maximum value in a time t. An emf, E, is induced across the coil.
What is the maximum value of the magnetic flux through the coil?

A $\dfrac{Et}{N}$

B $\dfrac{N}{Et}$

C EtN

D $\dfrac{E}{Nt}$

25 An aircraft, of wing span 60 m, flies horizontally at a speed of $150\,\text{m}\,\text{s}^{-1}$, If the vertical component of the Earth's magnetic field in the region of the plane is 1.0×10^{-5} T, what emf is induced across the wing tips of the plane?

A 0.09 V
B 0.90 V
C 9.0 V
D 90 V

END OF QUESTIONS

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For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
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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.

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**

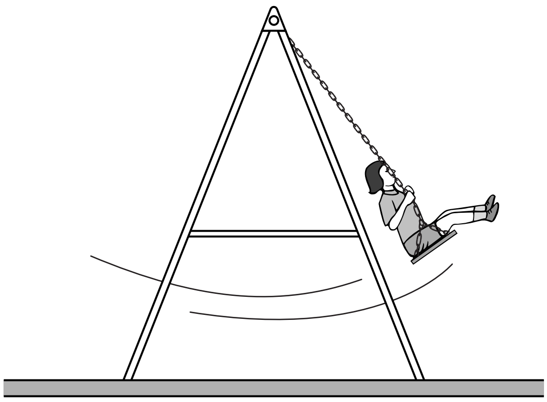


Figure 1 shows a young girl swinging on a garden swing. You may assume that the swing behaves as a simple pendulum. Ignore the mass of chains supporting the seat throughout this question, and assume that the effect of air resistance is negligible. 15 complete oscillations of the swing took 42s.

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)

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)

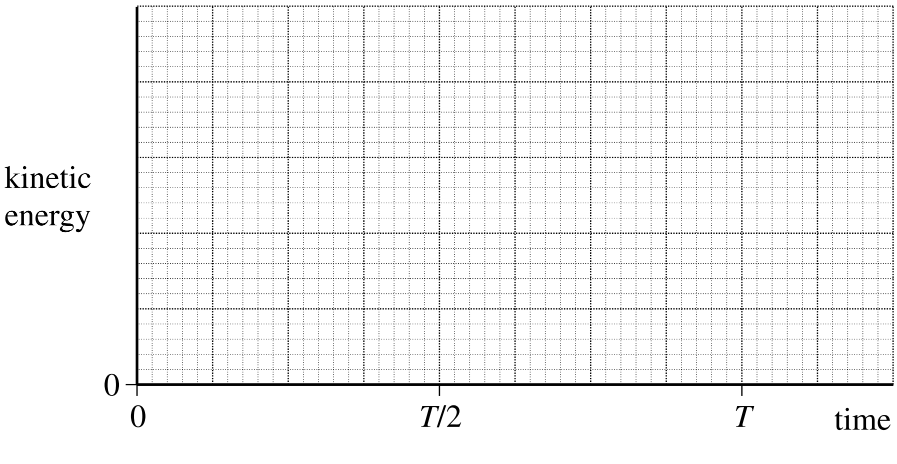
1 (b) (iii) Calculate the maximum speed of the girl during the first oscillation.

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

(1 mark)

1 (c)

Figure 2



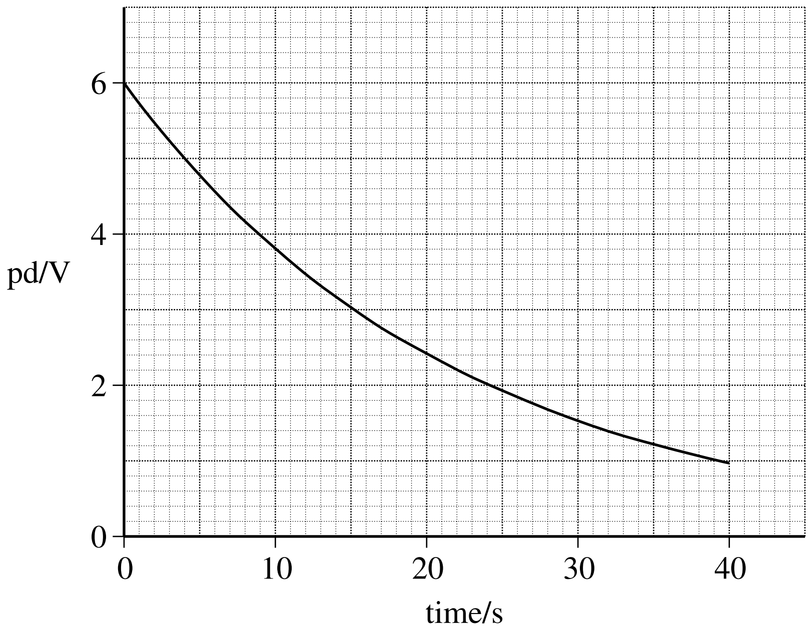
On **Figure 2** draw a graph to show how the kinetic energy of the girl varied with time during the first complete oscillation, starting at the time of her release from maximum displacement. On the horizontal axis of the graph, T represents the period of the swing. You do not need to show any values on the vertical axis.

(3 marks)

12

Turn over ▶

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)

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 ▶

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

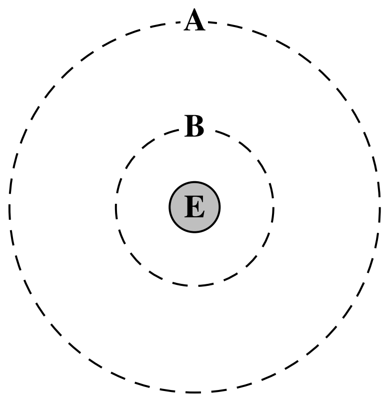

Figure 3 shows two of the orbits, **A** and **B**, that could be occupied by a satellite in circular orbit around the Earth, **E**.
The gravitational potential due to the Earth of each of these orbits is:

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)

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 ▶

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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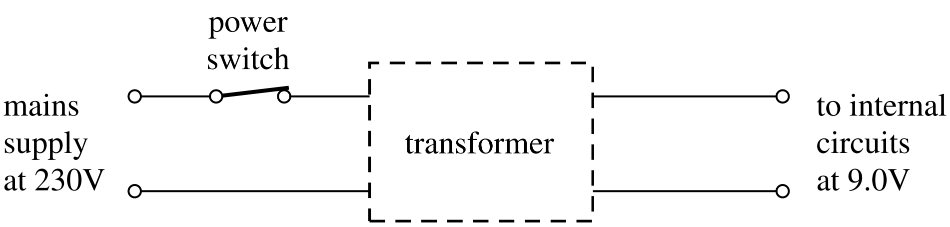
(6 marks)

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

Turn over ▶

Areas outside the box will not be scanned for marking

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

16

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