Surname		Other Names	
Centre Number		Candidate Number	
Candidate Signature			

For Examiner's Use

General Certificate of Education
June 2008
Advanced Level Examination

PHYSICS (SPECIFICATION B) **PHB4**
Unit 4 Further Physics

Wednesday 11 June 2008 9.00 am to 10.30 am

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

Time allowed: 1 hour 30 minutes

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.
- Show all your working.
- Do all rough work in this book. Cross through any work you do not want to be marked.

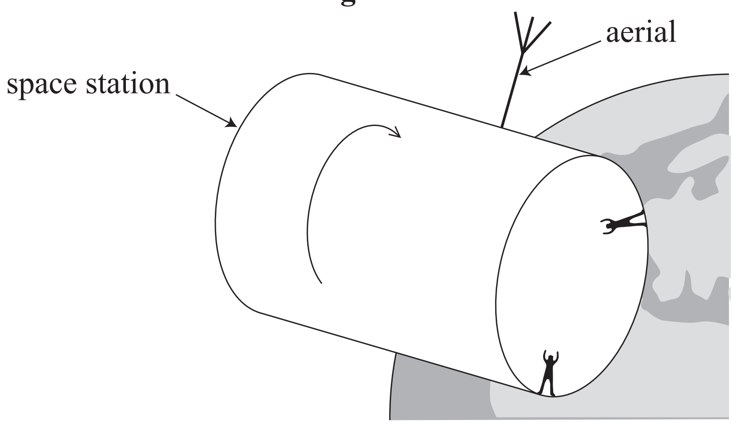
Information
- The maximum mark for this paper is 75. This includes up to 4 marks for the Quality of Written Communication.
- The marks for questions are shown in brackets.
- You are expected to use a calculator where appropriate.
- Questions 4(a) and 6(c) should be answered in continuous prose. In these questions you will be marked on your ability to use good English, to organise information clearly and to use specialist vocabulary where appropriate.
- A *Formulae Sheet* is provided as a loose insert to this question paper.

For Examiner's Use			
Question	Mark	Question	Mark
1			
2			
3			
4			
5			
6			
Total (Column 1) →			
Total (Column 2) →			
TOTAL			
Examiner's Initials			

Answer **all** questions.

1 **Figure 1** shows a space station that simulates gravity (artificial gravity). The station is designed in the shape of a cylinder which rotates about its long axis.

Figure 1



The station has a radius of 18 m and the apparent acceleration due to gravity at the walls of the station is to be 8.5 $m\,s^{-2}$.

1 (a) (i) Show that the required rotational speed of the station is about 0.7 $rad\,s^{-1}$.

1 (a) (ii) State and explain in which direction the artificial gravity acts.

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(4 marks)

1 (b) (i) Calculate the time for one revolution of the space station.

1 (b) (ii) The aerial for sending radio signals to Earth is placed on the side of the cylinder as shown in **Figure 1**. Explain why communication with the Earth will be difficult.

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(2 mark)

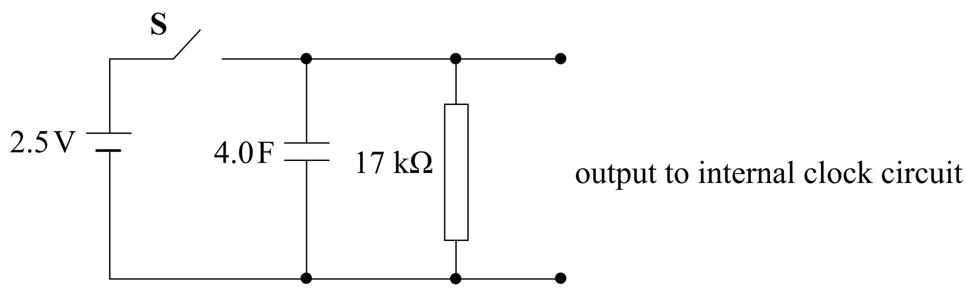
6

Turn over for the next question

2 Ultracapacitors have a large value of capacitance in a small package size and can be used for memory backup in computers.

2 (a) **Figure 2** shows an ultracapacitor being used in a computer circuit to backup the internal clock in the event of a power supply failure.

Figure 2



The ultracapacitor has a capacitance of C of 4.0 F with a voltage rating of 2.5 V. The resistance R of the circuit is 17 kΩ. Failure of the power supply is equivalent to opening switch **S**. Assume that no charge flows to or from the internal clock circuit itself.

2 (a) (i) Calculate the value of RC for this circuit.

2 (a) (ii) Calculate the potential difference across the clock circuit after a time of two time constants has elapsed.

(4 marks)

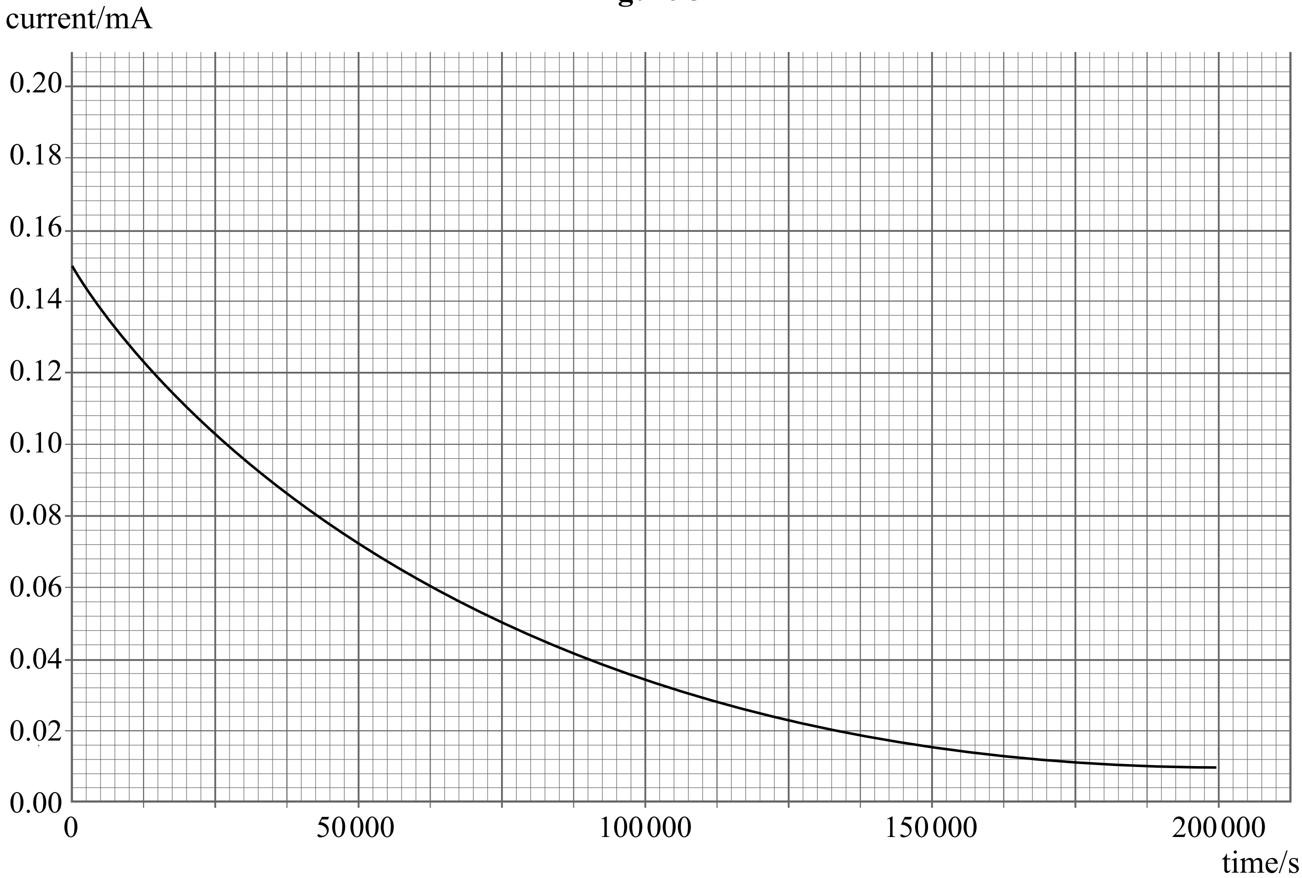
2 (b) One problem with an ultracapacitor is leakage current that allows the stored charge to drain away. The manufacturer quotes the leakage current as 20 μA when the potential difference across the capacitor is 2.5 V. Assume that the leakage current is directly proportional to the potential difference across the ultracapacitor.

2 (b) (i) The capacitor is fully charged to a potential difference of 2.5 V.

Calculate the total initial current in the resistor when the switch **S** is opened.

2 (b) (ii) **Figure 3** shows a sketch graph of the variation of current in the resistor *R* against time assuming no leakage current. Add a new line to show how the current in *R* varies with time when there is a leakage current.

Figure 3



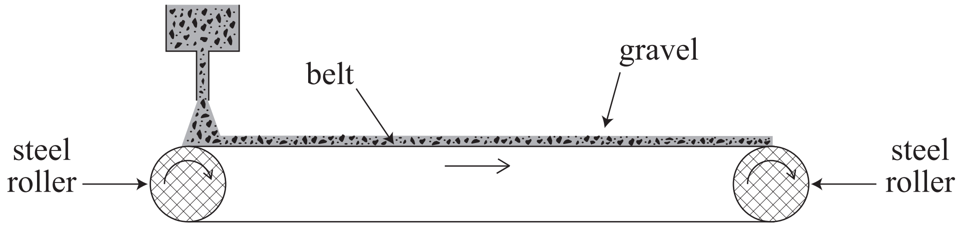
(5 marks)

9

Turn over ▸

3 **Figure 4** shows a conveyor belt moving gravel horizontally in a quarry. The gravel falls vertically onto the belt striking it with negligible initial kinetic energy.

Figure 4



3 (a) The gravel has an average depth of 0.11 m on the belt. The belt is 0.76 m wide. Every second, 48 kg of gravel falls onto the belt.

3 (a) (i) Show that the belt moves at a speed of about $0.3\,\mathrm{m\,s^{-1}}$.

effective density of gravel = $1.8 \times 10^{3}\,\mathrm{kg\,m^{-3}}$

3 (a) (ii) Calculate the force required to keep the belt moving steadily.

3 (a) (iii) The steel rollers are driven by an electric motor. Assume that there are negligible friction losses between the rollers and the belt and at the bearings of the rollers.

Calculate the energy delivered to the rollers by the electric motor every second.

(6 marks)

3 (b) (i) Show that, due to the change in horizontal motion as the gravel strikes the belt, the total kinetic energy gained every second by the gravel is about 2.5 J.

3 (b) (ii) Comment on the difference between the two energies calculated in part (a)(iii) and part (b)(i).

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(4 marks)

3 (c) (i) The conveyor belt is made of rubber, the rollers are made of steel.
Sketch on the axes below typical stress-strain curves for both rubber and steel.

Draw the curves to the same scale on both axes. Label the steel curve **S**.
Numerical values are not required.

Question 3 continues on the next page

Turn over

3 (c) (ii) The belt has a total length of 78 m when it is stationary with no gravel resting on it. The belt is 0.76 m wide and has a thickness of 0.14 m.
A total force of 2.6×10^4 N acts on the belt whilst the gravel is moving.
Calculate the extension of the belt.

Young modulus of belt rubber = 0.15 GPa

(6 marks)

16

4 (a) Matter is described as having a *wave–particle duality*.
Explain what this means and go on to outline how the two views are reconciled.

Two of the 6 marks in this question are for the quality of your written communication.

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(6 marks)

4 (b) One theory suggests that light behaves as a wave. In this model, light energy would be absorbed evenly over an entire surface. An electron near the surface of magnesium can absorb all the energy that falls on a single magnesium atom. When sufficient energy has been absorbed, the electron can escape from the surface.

4 (b) (i) A lamp delivers ultraviolet light to a magnesium surface. The energy delivered by the lamp per second to each square metre of the surface is 0.023 J.

For this model, estimate the time it would take for an electron to absorb sufficient energy to escape from the metal surface.

work function for magnesium $= 5.9 \times 10^{-19}$ J
area of a single magnesium atom $= 4.0 \times 10^{-19}$ m^2

Question 4 continues on the next page

Turn over ▸

4 (b) (ii) State and explain whether your estimate of the time in part (b)(i) is a maximum or a minimum value.

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(4 marks)

4 (c) Another theory suggests that light consists of a stream of particles called photons.

4 (c) (i) Show that, for ultraviolet light of wavelength 320 nm, the energy of one photon is about 6×10^{-19} J.

Planck constant $= 6.6 \times 10^{-34}$ J s
speed of light $= 3.0 \times 10^{8}$ m s^{-1}

4 (c) (ii) The magnesium surface has an area of 1.2×10^{-4} m^2. The energy delivered per second to each square metre of the surface by the ultraviolet light is 0.023 J. Calculate the number of photons that fall on to the magnesium surface each second.

4 (c) (iii) Calculate the maximum photoelectric current that will result from these photons if the magnesium forms the cathode of a photocell.

electron charge $= -1.6 \times 10^{-19}$ C

4 (c) (iv) Explain why your estimate of the photoelectric current in part (c)(iii) is a maximum.

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(6 marks)

16

Turn over for the next question

5 Motion that satisfies the equation

$$a = -\omega^2 x$$

is said to be simple harmonic.

5 (a) Give the meaning of the symbols in the equation.

a ....

ω ....

x ....

(3 marks)

Figure 5 shows a steel sphere, used to demolish a wall, swinging at the end of a cable attached to a crane. The graph **Figure 6** shows how the displacement of the sphere varies with time.

Figure 5

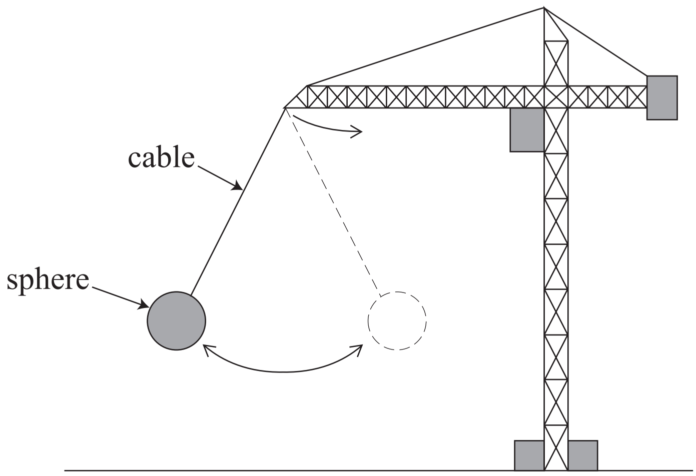
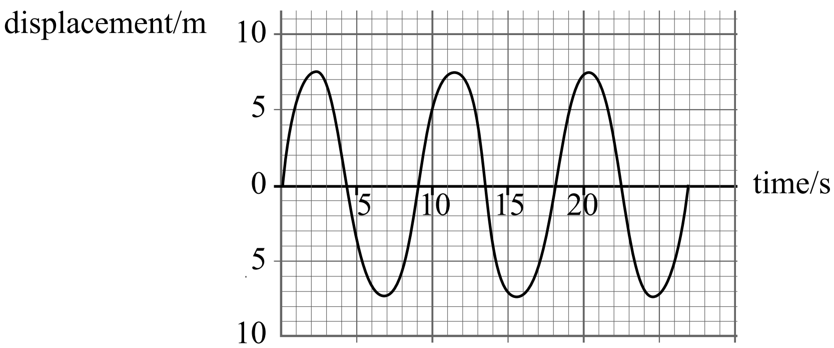


Figure 6



5 (b) (i) Calculate the frequency of the oscillation.

5 (b) (ii) Calculate the length of the cable.

gravitational field strength = $9.8\,N\,kg^{-1}$

(4 marks)

5 (c) (i) The sphere has a mass of 5.5×10^3 kg.
Calculate the maximum energy available for demolition.

5 (c) (ii) The energy you calculated in part (c)(i) is a maximum and not all of it will go into demolishing a wall. Suggest **two** other ways in which the energy of the sphere will be lost.

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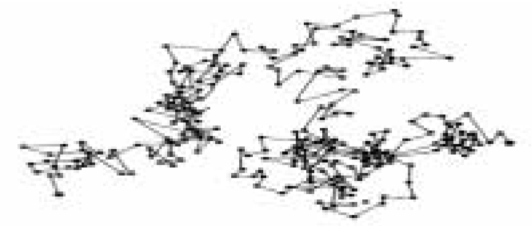
(5 marks)

12

Turn over ▸

6 In 1908 Jean Perrin plotted the positions of a dust particle in air at intervals of 30 s. **Figure 7** shows one set of his results.

Figure 7



6 (a) Explain Perrin's results.

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(2 marks)

6 (b) A student carries out an experiment in which a gas is cooled from 61 °C and the pressure of the gas is measured at various temperatures. The volume of the gas remains constant at $2.5 \times 10^{-4}\,\text{m}^3$ during the experiment. The first data point recorded by the student is at 61 °C with a pressure of $3.0 \times 10^{5}\,\text{Pa}$.

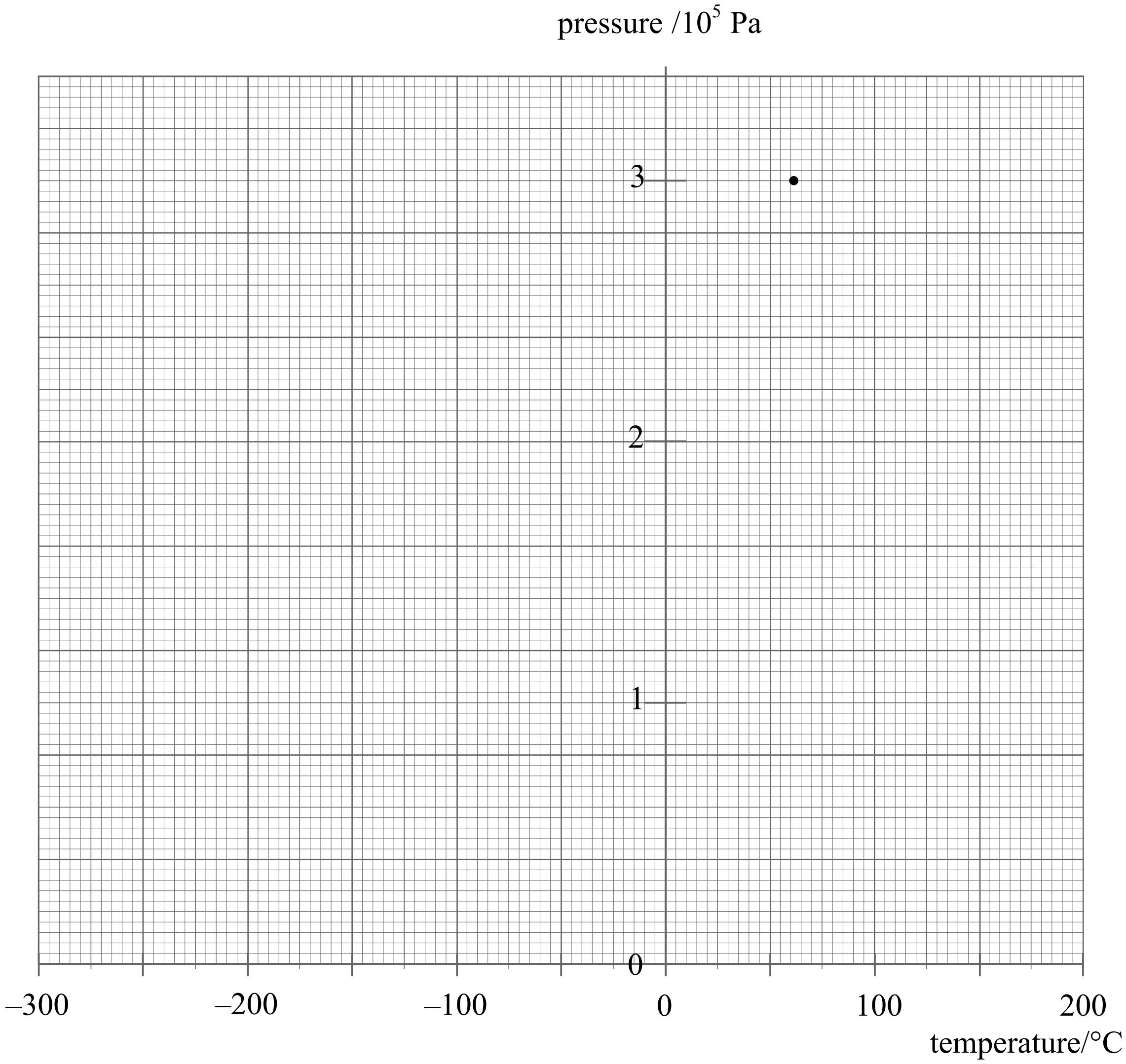
6 (b) (i) Calculate the number of molecules in the gas.

Avogadro constant = $6.0 \times 10^{23}\,\text{mol}^{-1}$
molar gas constant = $8.3\,\text{J}\,\text{mol}^{-1}\,\text{K}^{-1}$

Areas outside the box will not be scanned for marking

6 The first data point has already been plotted on the graph in **Figure 8.**

Figure 8



6 (b) (ii) Draw on **Figure 8** the graph you would expect the student to obtain. Label this line **A**.

6 (b) (iii) Draw on **Figure 8** the graph you would expect the student to obtain if the number of molecules under test were halved. Label this line **B**.

(2 marks)

Question 6 continues on the next page

6 (c) Pressure and temperature are properties of a gas that are explained through a model that assumes the existence of molecules.

Explain how the behaviour of the molecules is said to account for the pressure and temperature of the gas. Go on to explain how the pressure and temperature are related in this theory.

Two of the 6 marks in this question are for the quality of your written communication.

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(6 marks)

Areas outside the box will not be scanned for marking

6 (d) Discuss the application of the first law of thermodynamics to the gas in the experiment in part (b).

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(6 marks)

16

END OF QUESTIONS

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