Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
6	
TOTAL	

General Certificate of Education
Advanced Level Examination
January 2012

Physics (B): Physics in Context PHYB4

Unit 4 Physics Inside and Out

Module 1 Experiences Out of this World
Module 2 What Goes Around Comes Around
Module 3 Imaging the Invisible

Tuesday 24 January 2012 1.30 pm to 3.15 pm

For this paper you must have:
- a pencil and a ruler
- a calculator
- a Data and Formulae Booklet (enclosed).

Time allowed
- 1 hour 45 minutes

Instructions
- Use black ink or black ball-point pen. Use pencil only for drawing.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- Show all your working.

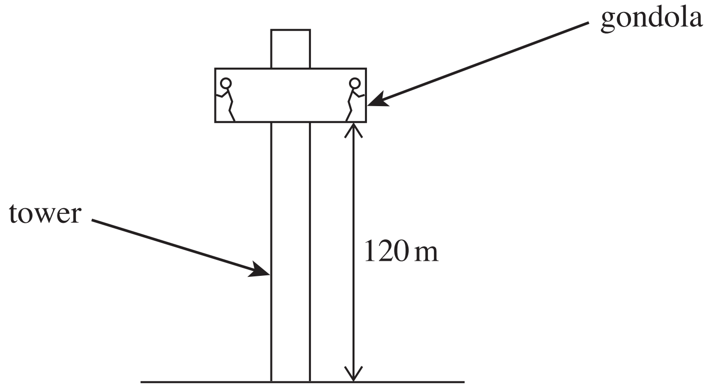
Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 100.
- You are expected to use a calculator where appropriate.
- A *Data and Formulae Booklet* is provided as a loose insert.
- You will be marked on your ability to:
  – use good English
  – organise information clearly
  – use specialist vocabulary where appropriate.

Do not write outside the box

Answer **all** questions in the spaces provided.

1 **Figure 1** shows a drop tower in an amusement park. A gondola, carrying riders, is raised vertically through 120 m. It is then released, falling 80.0 m before brakes decelerate the gondola uniformly until it reaches the ground.

Figure 1



1 (a) (i) Explain why a rider feels weightless when in freefall.

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(2 marks)

1 (a) (ii) Show that the maximum speed that the rider could reach is approximately 40 m s^{-1}.

(2 marks)

Do not write outside the box

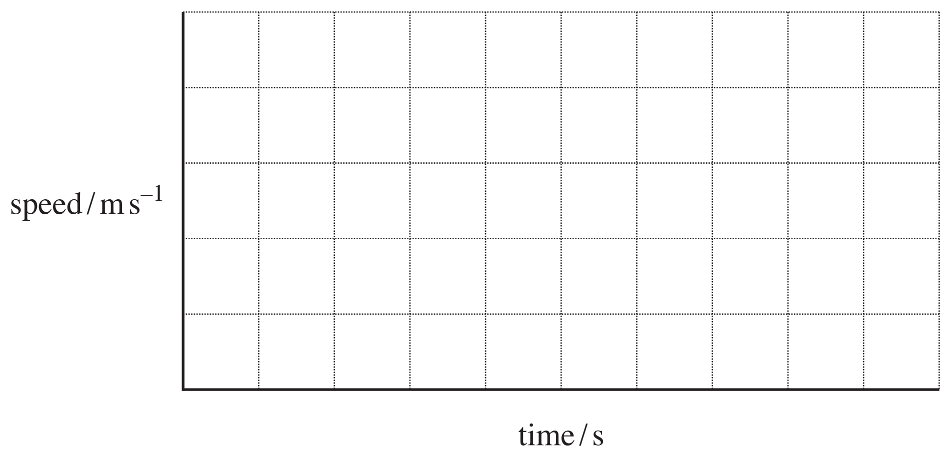
1 (a) (iii) Calculate the time taken to reach the maximum speed.

time .... s

(2 marks)

1 (b) When the brakes are applied they provide a constant upwards force and the gondola decelerates at 19.6 $m\,s^{-2}$.

1 (b) (i) Sketch how the rider's speed varies from release until the gondola reaches the ground. Show on your graph the time when the speed is maximum and the time that the gondola comes to rest.



(3 marks)

1 (b) (ii) State why the rider will feel heaviest while the brakes are being applied.

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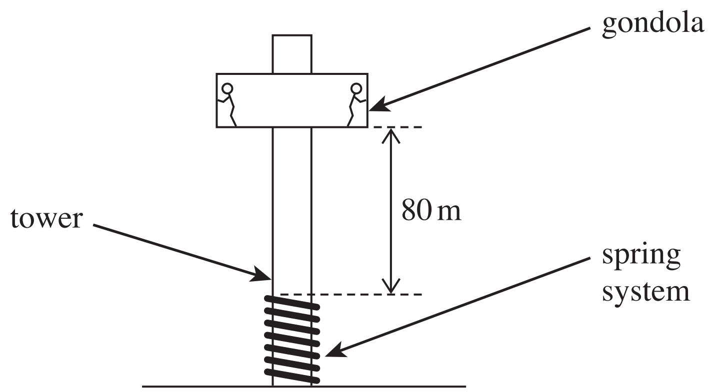
(1 mark)

1 (b) (iii) Calculate the reaction force on a rider of mass 75.0 kg during the final 40 m of descent.
Explain your calculation fully.

reaction force .... N
(2 marks)

1 (c) **Figure 2** shows a suggested variant of the ride in which the braking system is replaced by a spring. When the gondola falls 80 m, it attaches to the spring and compresses it by 15 m. Assume that the gondola now oscillates simple harmonically. The gondola and passengers have a total mass of 2300 kg.

Figure 2



1 (c) (i) Calculate the spring constant k of the system.
Give a suitable unit for k.

k .... unit ....
(3 marks)

1 (c) (ii) Use your value of *k* to calculate the period of oscillation of the gondola.

period of oscillation .... s

(2 marks)

1 (c) (iii) State and explain whether this design is likely to be safe whilst providing a suitable thrill for the rider.
You should perform any calculations which will support your answer.

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(3 marks)

20

Turn over for the next question

Do not write outside the box

2 **Figure 3** shows an amusement park ride in which two riders, **A** and **B** are positioned in cages at opposite ends of a supporting arm. The arm is rotated in a circle about a horizontal axis.
Each rider has a mass of 60.0 kg.
Figure 4 is an enlarged diagram of the lower cage **A** at the instant shown in **Figure 3**.

Figure 3

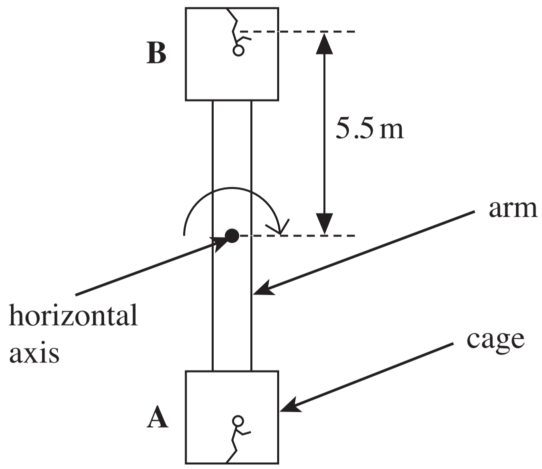
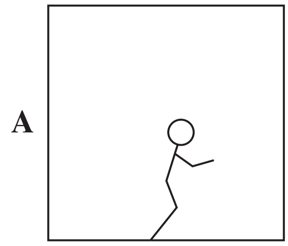


Figure 4



2 (a) (i) Mark on **Figure 4** labelled arrows to show the forces acting on rider **A** at the instant shown.

(2 marks)

2 (a) (ii) Explain how rider **B** can remain in contact with the floor when upside down.

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(2 marks)

2 (b) The period of rotation of the ride is 3.9 s.

2 (b) (i) Calculate the angular velocity of the ride.
Give an appropriate unit for angular velocity.

angular velocity .... unit ....

(2 marks)

2 (b) (ii) The centre of mass of each rider is 5.5 m from the axis of rotation.
Calculate the centripetal force acting on each rider.

centripetal force .... N

(1 mark)

2 (b) (iii) Calculate the normal reactions acting on riders **A** and **B** in the positions shown in **Figure 3**.

normal reaction on **A** .... N

normal reaction on **B** .... N

(3 marks)

Turn over ▶

Do not write outside the box

2 (c) On another occasion more people enter the two cages. It is found that it takes longer for the ride to reach its top angular speed than it does with fewer riders.
Explain why this should be so and go on to describe why the ride operators need to ensure that the total masses of each cage and the riders are equal.

The quality of your written communication will be assessed in this question.

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(6 marks)

16

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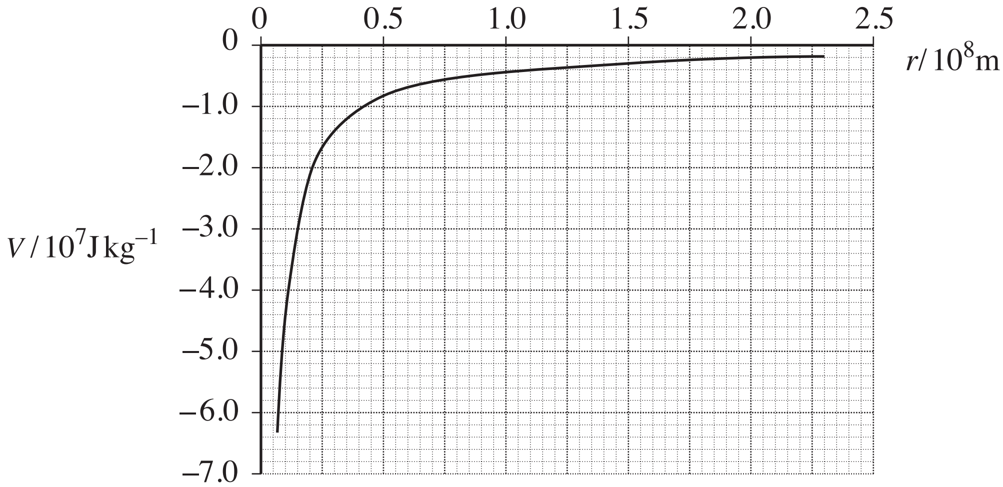
3 **Figure 5** shows the variation of gravitational potential, V, with distance from the centre of the Earth, r. The radius of the Earth is 6.4×10^6 m.

Figure 5



3 (a) Explain why the V values are negative.

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(3 marks)

3 (b) Use data from the graph to show that the mass of the Earth is approximately 6×10^{24} kg.

(3 marks)

Turn over ▶

3 (c) (i) Calculate the work done in raising a satellite of mass 2100 kg from the surface of the Earth to a height of 850 km above the surface of the Earth.

work done .... J

(3 marks)

3 (c) (ii) Calculate the change in the kinetic energy of the satellite when it moves from its 850 km orbit to one at a height of 700 km above the Earth's surface. Make it clear whether the change in kinetic energy is an increase or decrease.

kinetic energy change .... J

(4 marks)

3 (c) (iii) Without performing any further calculations explain how the change in kinetic energy relates to the change of the potential energy when the satellite's orbit alters as in part (c)(ii).

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(2 marks)

15

Turn over for the next question

4 Resistivity surveying is one of several techniques that can be used to determine the location of ores or building remains of archaeological interest without the need for excavation.

4 (a) List the names of **three** other techniques which can be used.

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(3 marks)

4 (b) **Figures 6** and **7** show the general layout in one method of resistivity surveying.
In **Figure 6** the soil is of uniform resistivity, in **Figure 7** the resistivity of the lower layer of soil is greater than that of the higher layer.
$\mathbf{P_1}$, $\mathbf{P_2}$, $\mathbf{P_3}$ and $\mathbf{P_4}$ are probes embedded in the soil.

Figure 6

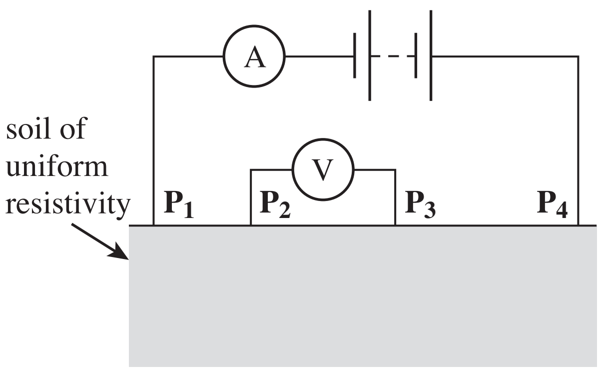
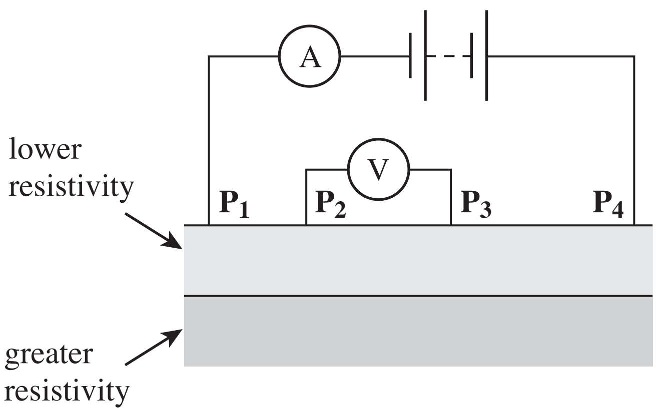


Figure 7



4 (b) (i) On **Figure 6** mark **four** possible conventional current paths.

(1 mark)

4 (b) (ii) Mark on **Figure 7** the conventional current paths in each of the soil types.

(1 mark)

4 (b) (iii) Explain why you have drawn your paths in this way.

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(2 marks)

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4 (c) **Figure 8** is a plot of some data obtained by resistivity surveying. **Figure 9** is a table of some typical resistivities of soils.

Figure 8

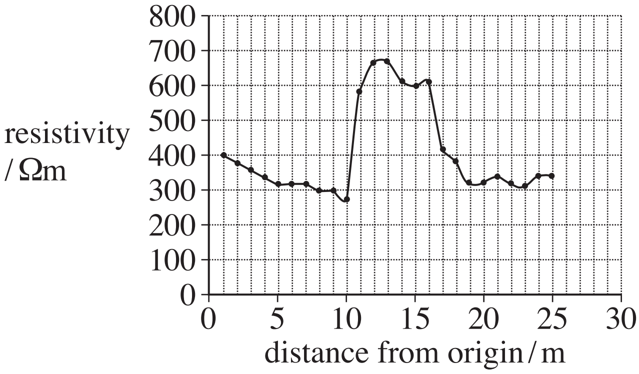

Figure 9

soil type	resistivity /Ωm
top soil	50-100
clay	100-500
sandy	500-5000
clay and marl	1-100
limestone	80-1000
sandstone	500-5000

4 (c) (i) What can you deduce about the soil types from the resistivity survey?

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(3 marks)

4 (c) (ii) Suggest **two** drawbacks of resistivity surveying.

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(2 marks)

12

Turn over ▶

5 MRI scanners use superconducting magnets to produce strong magnetic fields which pass through the patient being scanned. The nuclei of hydrogen atoms are protons which usually spin with random orientation in the body. When the magnetic field is applied the protons partially align but not sufficiently to prevent them from precessing about the magnetic field lines. The angular frequency of precession of the protons ω is given by

$$\omega = kB_0$$

where B_0 is the applied magnetic field strength and k has a magnitude of 2.6×10^8 for protons. An applied radio frequency pulse causes the protons to change their frequency of precession. This causes a changing magnetic field which induces an emf in a detecting coil. The emf is a maximum when the frequency of the pulse is equal to the frequency of precession.

5 (a) (i) State the characteristic property of a superconductor.

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(2 marks)

5 (a) (ii) Explain why superconductors are ideally suited for generating magnetic fields in MRI scanners.

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(2 marks)

5 (b) (i) Determine the unit of the constant k.

unit ....

(2 marks)

5 (b) (ii) Calculate the frequency of precession of protons when B_0 is 2.5 T.

frequency of precession .... Hz

(3 marks)

5 (c) Suggest why the frequency of the radio frequency pulse is most effective when it is matched to the frequency of precession of the protons.

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(2 marks)

5 (d) A magnetic field emitted by precessing protons changes at a rate of 2.25 $\mu T\,s^{-1}$.
Calculate the emf induced in a 2000 turn detecting coil of area 7.8×10^{-3} m^2.

induced emf V

(3 marks)

Do not write outside the box

5 (e) State **two** advantages and **two** disadvantages of MRI scanning compared with X-ray imaging.

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(4 marks)

18

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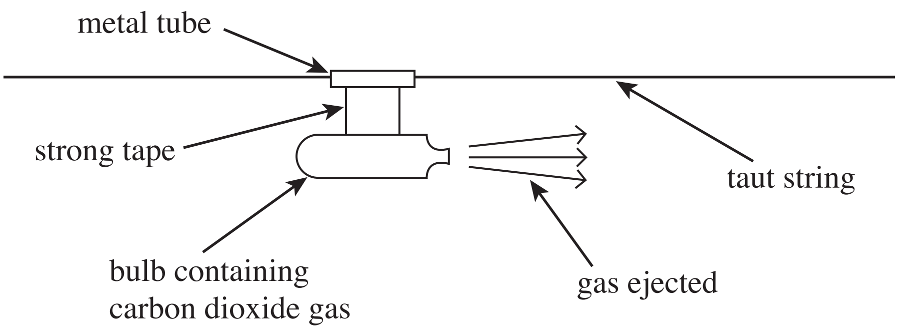
6 **Figure 10** shows an arrangement for demonstrating rocket propulsion in a teaching laboratory.
A small hole is made in the end of the bulb containing carbon dioxide at high pressure and gas is ejected through the hole. The bulb is then propelled rapidly along the taut string.

Figure 10



6 (a) Initially the pressure is 6.0×10^6 Pa and the volume of the bulb is 1.5×10^{-5} m^3. As the gas leaks out of the bulb the pressure rapidly falls.

6 (a) (i) Assuming that the carbon dioxide is an ideal gas estimate the initial number of moles of gas in the bulb when its temperature is 20 °C.

number of moles ....

(3 marks)

6 (a) (ii) Explain why the carbon dioxide initially filling the bulb should not be considered to behave as an ideal gas.

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(2 marks)

Do not write outside the box

6 (b) It is noticed that as the carbon dioxide leaves the bulb rapidly the surface of the bulb becomes very cold.
Describe how the first law of thermodynamics explains why the bulb becomes very cold.

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(4 marks)

6 (c) Outline how this demonstration of the motion of the bulb can be explained in terms of the conservation of momentum.

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(3 marks)

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6 (d) The bulb moves with a maximum speed of $18\,m\,s^{-1}$. The bulb has a mass of 85 g when it is empty. The gas is ejected in a time of 5.0×10^{-2} s.

6 (d) (i) Estimate the average thrust on the bulb.

average thrust .... N

(3 marks)

6 (d) (ii) Without performing a calculation explain how the maximum speed of the ejected gas compares with the final speed of the bulb.

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(2 marks)

6 (e) Suggest why a carbon dioxide rocket has limited practical use.

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(2 marks)

19

END OF QUESTIONS

There are no questions printed on this page

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