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 2010

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

Thursday 28 January 2010 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.

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. 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.

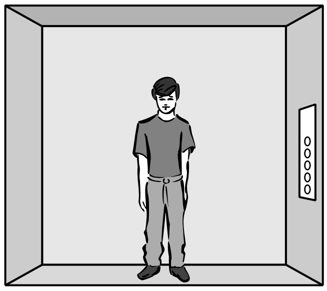
Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 100.
- You are expected to use a calculator where appropriate.
- A *Data and Formulae Booklet* is provided as a loose insert.
- You will be marked on your ability to:
  – use good English
  – organise information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

Areas outside the box will not be scanned for marking

Answer **all** questions.

1 (a) **Figure 1** shows a rider standing in a stationary lift. The rider's mass is 67 kg.

Figure 1



1 (a) (i) Mark and label on **Figure 1** the vertical forces acting on the rider.

(2 marks)

1 (a) (ii) Calculate the weight of the rider.

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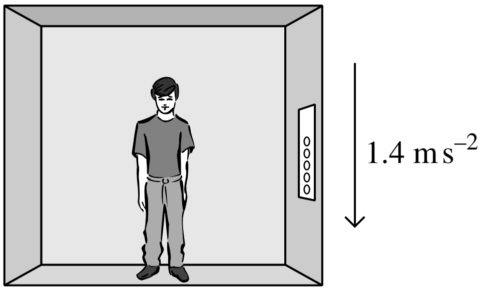
weight .... N

(1 mark)

Areas outside the box will not be scanned for marking

1 (a) (iii) **Figure 2** shows the rider in the lift which is accelerating downwards with an acceleration of $1.4\,m\,s^{-2}$.

Figure 2



Explain why the rider feels that his weight is reduced.
You should perform a suitable calculation to support your answer.

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(4 marks)

1 (b) Explain why a skydiver in free fall experiences the sensation of weightlessness.

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(1 mark)

Question 1 continues on the next page

1 (c) When the skydiver is in free fall the *viscosity* of the air affects her motion. Eventually the skydiver will reach her terminal velocity.

1 (c) (i) What is meant by viscosity?

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(2 marks)

1 (c) (ii) The equation for Stokes' law is

$$F = 6\pi\eta r v$$

Using this equation, derive a suitable unit for viscosity.

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unit for viscosity ....

(3 marks)

1 (c) (iii) State **two** reasons why Stokes' law cannot be applied to the motion of a skydiver.

reason 1 ....

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reason 2 ....

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(2 marks)

15

2 (a) The mass of the space shuttle is approximately 2.0×10^6 kg.

2 (a) (i) Show that the gravitational potential energy of the shuttle when it is on the Earth's surface is approximately -1.3×10^{14} J.

mass of the Earth = 5.97×10^{24} kg
radius of the Earth = 6.37×10^6 m

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(2 marks)

2 (a) (ii) Explain why the gravitational potential energy has a negative value.

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(3 marks)

2 (b) The shuttle is launched and takes up an orbit at a constant height of 3.5×10^5 m above the surface of the Earth.

2 (b) (i) Calculate the new gravitational potential energy of the shuttle.

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gravitational potential energy .... J
(2 marks)

Question 2 continues on the next page

Turn over ▶

2 (b) (ii) Explain the difference in the values calculated in part (a)(i) and part (b)(i).

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(2 marks)

2 (c) The space shuttle's propulsion system includes liquid propellant rockets.

2 (c) (i) Name **four** main features of a commercial liquid propellant rocket.

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(4 marks)

Areas outside the box will not be scanned for marking

2 (c) (ii) Explain how propulsion is achieved with a liquid propellant rocket. Make reference to features that you have named in part (c)(i) and to the conservation of momentum.

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

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(6 marks)

2 (c) (iii) Explain why launching the space shuttle using multi-stage rockets is inefficient.

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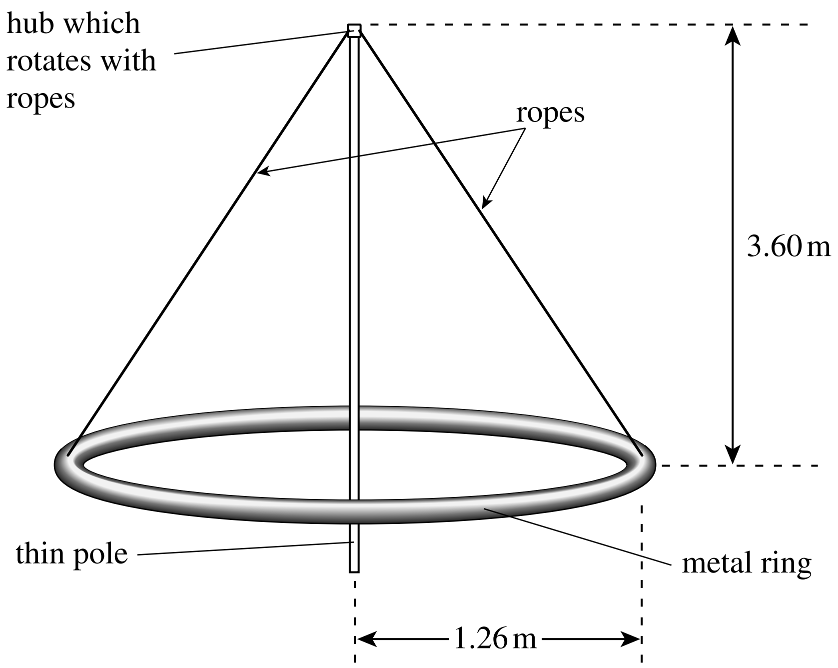
(2 marks)

21

Turn over ▶

3 **Figure 3** shows one type of playground roundabout. It consists of a rigid, hollow, metal ring supported by eight ropes arranged symmetrically around the ring. Two of the ropes are shown. The ring is of average radius 1.26 m and has a mass of 27.0 kg. The vertical distance from the ring to the hub where the ropes are attached is 3.60 m.

Figure 3



3 (a) (i) The metal ring is uniform and its weight is distributed evenly amongst the eight ropes.
Calculate the tension in one of the ropes when the roundabout is stationary.

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tension .... N
(4 marks)

Areas outside the box will not be scanned for marking

3 (a) (ii) The roundabout is set in motion. The metal ring freely rotates at a steady rate in a horizontal plane about the thin pole.
State and explain whether the tension in the ropes changes.

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(2 marks)

3 (b) Two children, each of mass 22 kg, sit facing each other on the ring. The roundabout is rotated about the thin pole with a period of 6.4 s. The children do not slip.

Calculate the horizontal force acting on each child.

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force .... N

(3 marks)

3 (c) The children turn around and now sit with their legs on the outside of the ring without holding a rope.
Explain why they are likely to slip off the roundabout when it is rotating quickly.

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(2 marks)

Question 3 continues on the next page

Turn over ▶

3 (d) When the children sit on the ring the *moment of inertia* of the ring increases from $42.9\,kg\,m^2$ to $113\,kg\,m^2$.

3 (d) (i) Explain what is meant by the term moment of inertia.

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(2 marks)

3 (d) (ii) Show that the torque needed to accelerate the ring (with no children) from rest to $1.3\,rad\,s^{-1}$ in a time of 5.7 s is approximately 10 Nm.

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(3 marks)

3 (d) (iii) The same torque of 10 Nm is now used to accelerate the ring with the children sitting on it.
Calculate how much longer it takes to accelerate the ring with the children on it from rest to $1.3\,rad\,s^{-1}$ compared with accelerating the ring alone.

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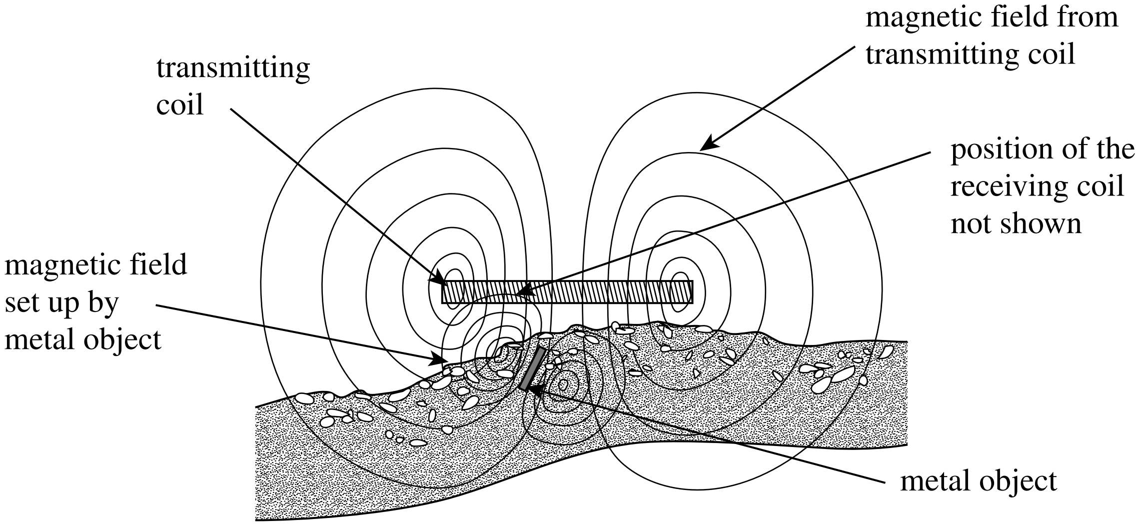
time .... s

(3 marks)

19

4 Metal detectors can be used for determining the position of metal objects buried beneath the surface of the ground. Some metal detectors use electromagnetic induction in order to induce eddy currents in metal objects. **Figure 4** shows part of a metal detector in which a pulse of current in the transmitting coil induces eddy currents in the metal object. The eddy currents set up a magnetic field around the metal object, this changing field is detected by the receiving coil. The receiving coil is shielded from the transmitting coil.

Figure 4



4 (a) (i) State Faraday's laws of electromagnetic induction.

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(2 marks)

4 (a) (ii) State Lenz's law.

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(1 mark)

Question 4 continues on the next page

Turn over ▶

4 (a) (iii) Explain how these laws relate to the induction of eddy currents in the metal object.

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(3 marks)

4 (a) (iv) Suggest why it is important that the receiving coil is shielded from the transmitting coil.

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(2 marks)

4 (b) (i) The pulses of current produced in the transmitting coil occur at a period of 8.0 μs.
Calculate the frequency of the current.

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frequency .... Hz
(1 mark)

Areas outside the box will not be scanned for marking

4 (b) (ii) The flux density of the magnetic field produced by the metal object changes at a rate of $24\,\text{mT}\,\text{s}^{-1}$.
Calculate the emf induced in a circular receiving coil of diameter 28 cm and having 45 turns.
Assume that 15% of the flux produced by the metal object passes through the receiving coil.

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emf V
(4 marks)

4 (c) Name **two** situations in which metal detectors can be used to assist with the enforcement of national or international security.

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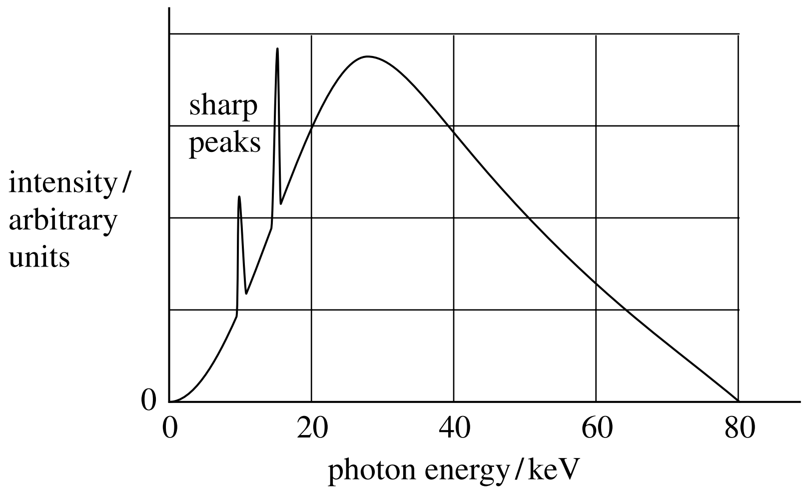
(2 marks)

15

Turn over ▶

5 (a) **Figure 5** shows the X-ray spectrum emitted from an X-ray tube with a potential difference of 80 kV supplied to it.

Figure 5



5 (a) (i) Sketch on **Figure 5** the expected X-ray spectrum when a potential difference of 60 kV is supplied to the tube.

(2 marks)

5 (a) (ii) Explain why the spectrum has sharp peaks at specific photon energies.

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(3 marks)

5 (b) (i) Calculate the speed of the electrons reaching the anode when the tube operates at 80 kV. Ignore relativistic effects.

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speed of electrons .... $m\,s^{-1}$

(3 marks)

5 (b) (ii) When the tube is operating at 80 kV its efficiency is 0.60%. The anode current in the tube is 140 mA.
Calculate the rate of production of internal energy in the anode, giving your answer to a suitable number of significant figures.

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rate of production of internal energy .... $J\,s^{-1}$

(4 marks)

5 (c) Explain the benefits of using a contrast medium when using X-rays for medical diagnoses.

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(3 marks)

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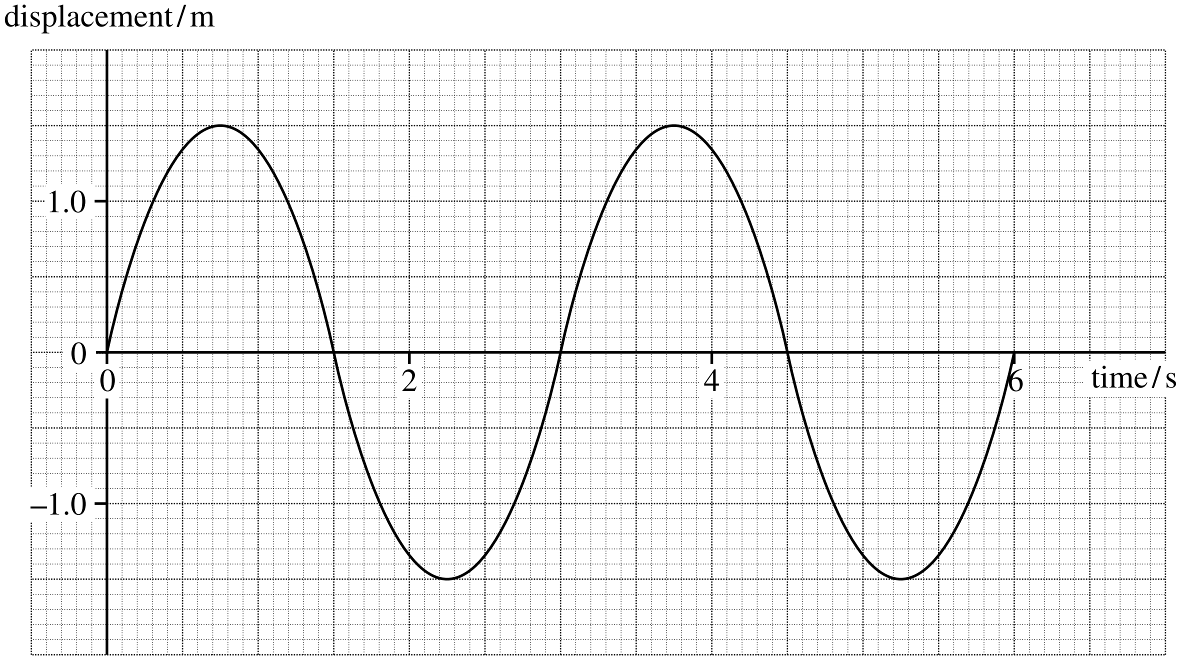
Turn over ▶

6 **Figure 6** shows a graph of the displacement of a child on a swing against time.

Figure 6



6 (a) (i) Using information from **Figure 6** calculate the maximum speed of the child.

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maximum speed .... $m\,s^{-1}$

(4 marks)

6 (a) (ii) Calculate the maximum acceleration of the child.

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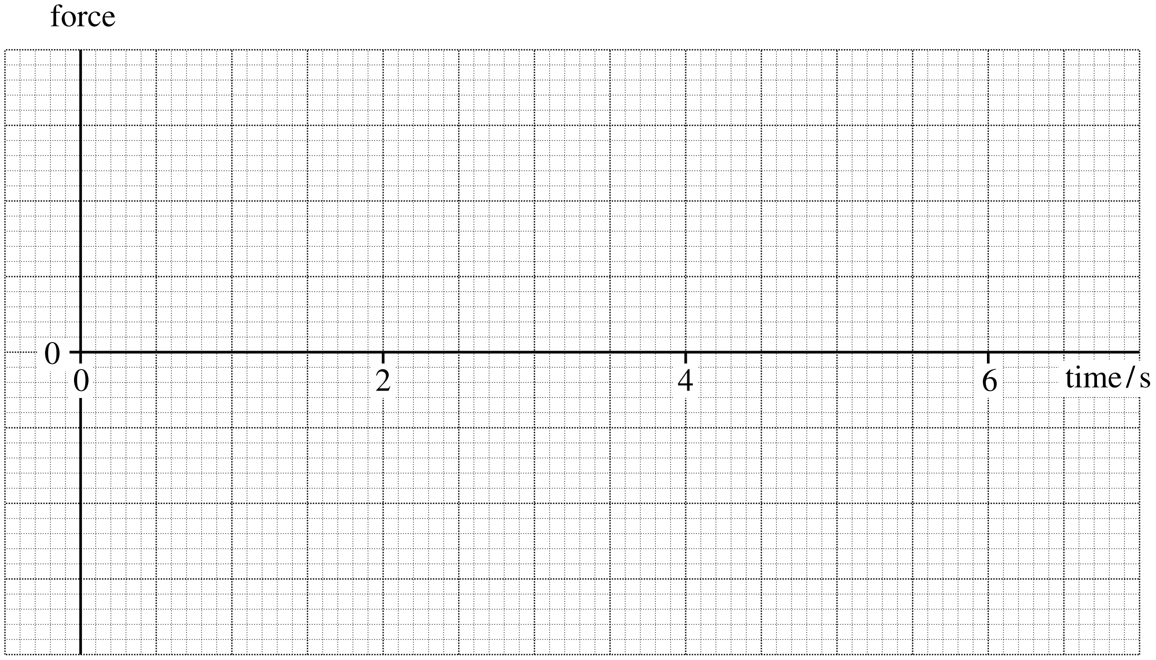
maximum acceleration .... $m\,s^{-2}$

(2 marks)

6 (b) A person standing at one extreme of the oscillation pushes the child on the swing so that the amplitude of the swing gradually increases to a maximum.
On **Figure 7** sketch a graph showing how the force could be provided in each cycle.

Figure 7



(3 marks)

6 (c) Pushing the child on the swing is an example of a *forced oscillation* causing *resonance*.

6 (c) (i) Explain what is meant by the term forced oscillation.

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(2 marks)

Question 6 continues on the next page

Turn over ▶

6 (c) (ii) Explain what is meant by resonance.

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(2 marks)

6 (c) (iii) Explain how the child can cause the swing to resonate without the need for being pushed.

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(2 marks)

15

END OF QUESTIONS

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