Centre Number						Candidate Number				
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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
June 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

Monday 11 June 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.

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.

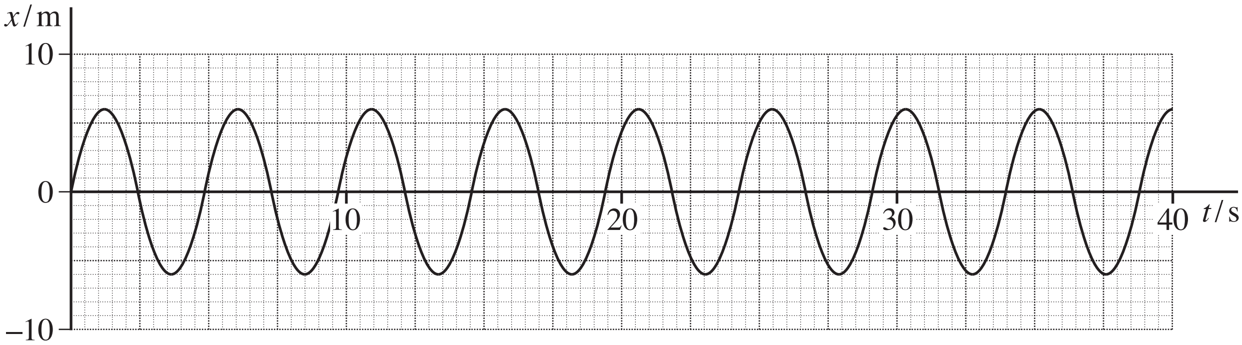
Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 100.
- You are expected to use a calculator where appropriate.
- A *Data and Formulae Booklet* is provided as a loose insert.
- You will be marked on your ability to:
  – use good English
  – organise information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

Do not write outside the box

Answer **all** questions.

1 A pirate ship is a type of amusement park pendulum ride in which a gondola carrying passengers is made to oscillate. The ride can be modelled using a simple pendulum consisting of a mass on a string.
Figure 1 shows how the displacement x of the mass varies with time t.

Figure 1



1 (a) (i) Define amplitude.

....

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(1 mark)

1 (a) (ii) Determine the amplitude of the oscillations of the mass.

amplitude .... m
(1 mark)

1 (a) (iii) Calculate the period of the pendulum.

period .... s
(2 marks)

Do not write outside the box

1 (b) Another model was constructed using a pendulum of frequency 0.25 Hz with the mass having an initial amplitude of 4.5 m.

1 (b) (i) Calculate the maximum velocity of the mass.

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

(2 marks)

1 (b) (ii) Calculate the maximum acceleration of the mass.

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

(2 marks)

1 (b) (iii) Calculate the length of the simple pendulum that has a frequency of 0.25 Hz.

length .... m

(2 marks)

1 (c) To simplify the driving mechanism of the actual ride it is suggested that the gondola should be pushed each time it reaches the centre moving in one direction.
Explain why this would lead to large amplitude oscillations.

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(2 marks)

1 (d) When the force is no longer applied the gondola will naturally come to rest. The time for this to happen will usually be too long to satisfy the ride operators. External dampers are used to reduce the time taken to stop the gondola.
Explain why the gondola would come to rest naturally and what feature of an energy efficient ride design would make this a lengthy process.

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(3 marks)

15

2 The use of endoscopes is common in medical diagnosis.

Endoscopes use optical fibres which are grouped in either *coherent* or *non-coherent* bundles.

2 (a) (i) Describe how the fibres are arranged in each type of bundle.

coherent bundle

....

....

non-coherent bundle

....

....

(2 marks)

2 (a) (ii) State an application for each type of bundle.

coherent bundle ....

....

....

non-coherent bundle ....

....

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(2 marks)

2 (b) (i) Suggest **two** advantages of using a coherent bundle consisting of fibres of very small diameter rather than a bundle consisting of larger diameter fibres.

advantage 1 ....

....

....

advantage 2 ....

....

....

(2 marks)

2 (b) (ii) Give **two** reasons why glass cladding is used around the core of each fibre in a coherent bundle.

reason 1 ....

....

....

reason 2 ....

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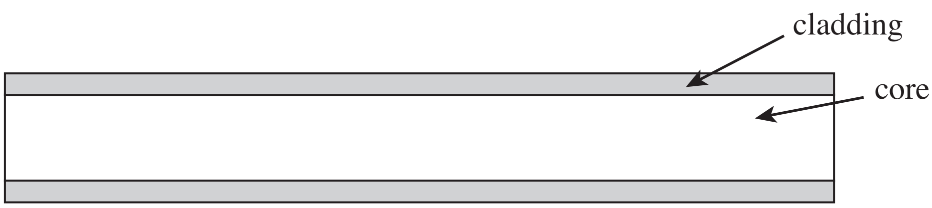
(2 marks)

2 (c) **Figure 2** shows a fibre consisting of a core and cladding.

refractive index of core = 1.52
refractive index of cladding = 1.40

Figure 2



2 (c) (i) Calculate the critical angle for the fibre.

critical angle .... degrees

(2 marks)

2 (c) (ii) When passing through the fibre light rays undergo total internal reflection.
Mark on **Figure 2** the path of a light ray passing through the fibre.

(1 mark)

Do not write outside the box

2 (d) Charge coupled devices (CCDs) are commonly used with endoscopes.

2 (d) (i) Give **two** advantages of using CCDs rather than using photographic film.

advantage 1 ....

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advantage 2 ....

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(2 marks)

2 (d) (ii) Explain how a CCD records the light intensity at a given point.

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(3 marks)

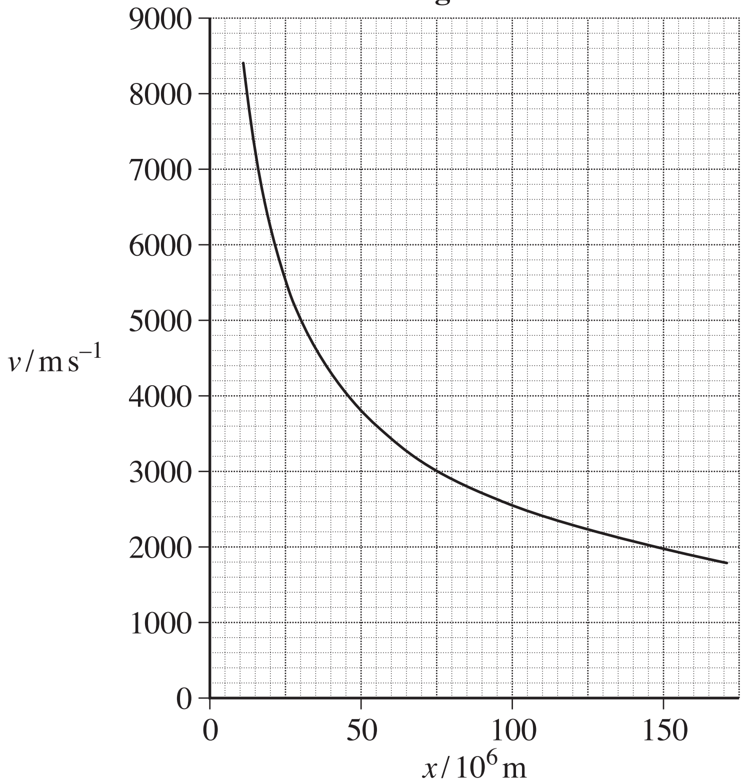
16

Turn over for the next question

Do not write outside the box

3 An unpowered space module of mass 3.0×10^4 kg approaches the Earth's atmosphere. **Figure 3** shows how the velocity, v, of the module varies with distance, x, from the surface of the Earth.

Figure 3



3 (a) (i) Determine whether or not the graph suggests that v is inversely proportional to x.

(3 marks)

3 (a) (ii) Calculate the change in kinetic energy as x changes from 1.7×10^8 m to 2.0×10^7 m.

change in kinetic energy .... J

(3 marks)

3 (a) (iii) State the value of the change in gravitational potential energy of the module as it falls through this distance and explain why the gravitational potential energy changes.

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(2 marks)

3 (a) (iv) Explain the relationship between gravitational potential and gravitational potential energy.

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(2 marks)

3 (b) The data for **Figure 3** relate to the command module for the Apollo 11 mission which took place in 1969. The command module was effectively the *payload* which returned to Earth having landed on the Moon. The 'power unit' for the initial launch from Earth was a Saturn 5 rocket which was a multistage liquid-fuelled expendable rocket. The first stage of the rocket used a propellant comprising refined petroleum and liquid oxygen. The resultant upward force on the Apollo 11 spacecraft when the rocket motor was fired was 34×10^6 N. The initial total mass of all the stages was 2.95×10^6 kg.

3 (b) (i) State the meaning of the term payload and go on to explain why NASA used a multistage rocket instead of a rocket with a single stage.

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(4 marks)

Turn over ▶

3 (b) (ii) Explain the purpose of transporting oxygen.

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(1 mark)

3 (b) (iii) Calculate the minimum velocity that the first stage of the rocket could have reached in the first 15 s after being launched. Assume the upward force was constant.
Give your answer to an appropriate number of significant figures.

minimum velocity .... m s^{-1}

(4 marks)

3 (b) (iv) Explain why this is the minimum velocity that the rocket could reach in the first 15 s of flight.

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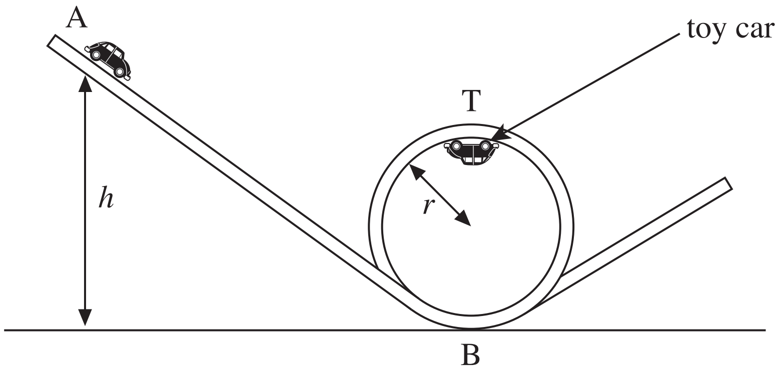
(2 marks)

21

4 Before constructing a section of a rollercoaster ride, a designer builds the model shown in **Figure 4**. The car is released at **A** and rolls down the track entering the looped section at **B**.

Figure 4



The looped section of the track has radius r. When the car reaches the top of the track, at the position marked **T**, its speed is v.

4 (a) (i) Explain how the toy car is able to remain on the track when it reaches **T**.

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(3 marks)

4 (a) (ii) The car remains in contact with the track at **T**. Show that the minimum speed which the car requires at **T** is given by $v_{min}=\sqrt{gr}$, where g is the gravitational field strength. State any assumptions that you make.

....

....

(3 marks)

Turn over ▶

Do not write outside the box

4 (a) (iii) The vertical distance between **A** and **B** is h.
Calculate the minimum value of h needed for the car to stay in contact with the track when r is 0.16 m.

minimum value of h .... m
(3 marks)

4 (b) In an earlier version of the model the designer had used a marble instead of the toy car. The marble had the same mass as the car but rolled along the edges of the track so that it had rotational kinetic energy as well as linear kinetic energy.
State and explain how the value of h needed for the marble to remain in contact with the track compares with that calculated for the car in (a)(iii).

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(2 marks)

4 (c) At one position on the track a marble, of radius 6.25×10^{-3} m, rolled at a speed of $1.6\,\text{m}\,\text{s}^{-1}$ without slipping. The moment of inertia of the marble was $3.92 \times 10^{-8}\,\text{kg}\,\text{m}^2$.

4 (c) (i) State what is meant by the moment of inertia of the marble. Identify the quantities upon which the moment of inertia depends.

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(2 marks)

Do not write outside the box

4 (c) (ii) Calculate the rotational kinetic energy of the marble.

rotational kinetic energy .... J

(4 marks)

4 (d) A piece of debris fell onto the rolling marble and increased its moment of inertia to 3.94×10^{-8} kg m^2. The initial angular speed of the marble was 181 rad s^{-1}.
Calculate the new angular speed of the marble.

new angular speed .... rad s^{-1}

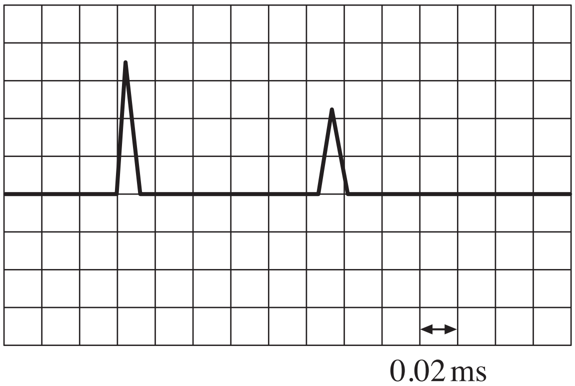
(3 marks)

20

Turn over for the next question

5 **Figure 5** shows the trace of an ultrasound scan of a patient's stomach. The pulses shown on the trace come from the near and far surfaces of the stomach relative to the ultrasound transmitter/receiver.

Figure 5



5 (a) (i) Estimate the distance between the near and far surfaces of the stomach.
The speed of ultrasound through the body tissue is $1500\,m\,s^{-1}$.

distance .... m
(4 marks)

5 (a) (ii) Give **two** reasons why the height of the second pulse is smaller than that of the first pulse.

first reason ....

....

second reason ....

....
(2 marks)

5 (b) Describe how an image of the stomach is obtained using ultrasound. Explain both why a gel must be applied to the abdomen of the patient and how the characteristic features of ultrasound enable a detailed image to be formed.

The quality of your written communication will be assessed in your answer.

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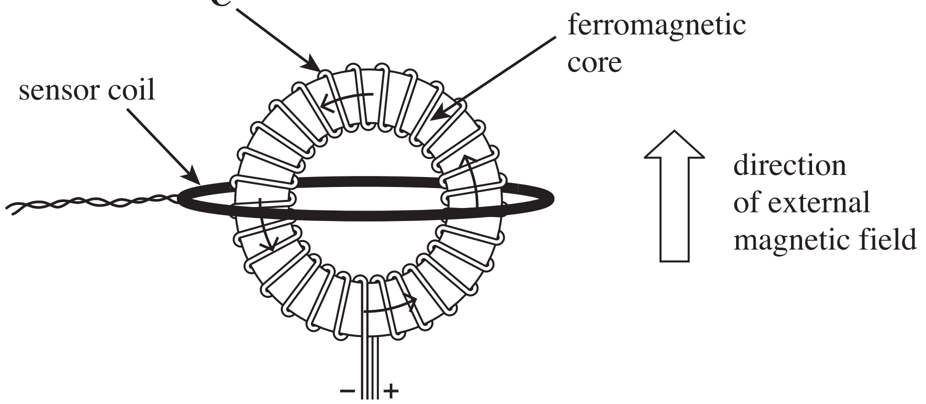
(6 marks)

12

Turn over for the next question

6 **Figure 6** shows part of a fluxgate magnetometer used to detect *magnetic anomalies*. This consists of a small ring-shaped ferromagnetic core with a coil **C** wrapped around it. When there is a direct current in **C**, a magnetic field is produced inside it in the direction shown by the curved arrows. When there is an external magnetic field, in the direction shown by the large arrow, the magnetic field in the core is in the same direction as the external field on the right hand side and in the opposite direction on the left. When alternating current is used to magnetise the core, the fields in the core cancel and there is no induced emf in a sensor coil wrapped around the main coil. In an external magnetic field the core on the right hand side reaches the maximum possible flux density (called magnetic saturation) before that on the left hand side because of the stronger resultant field. The flux density on the left hand side continues to change so there is an induced current in the sensor coil. The magnitude of this induced emf increases as the strength of the external field increases and the magnetometer can be calibrated to measure the flux density of the external field.

Figure 6



6 (a) (i) Define the term magnetic flux density.

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(2 marks)

6 (a) (ii) Give the name of the SI unit of magnetic flux density.

....

(1 mark)

6 (a) (iii) State what type of quantity the magnetic flux density is and explain the consequences of this for calculating an overall magnetic flux density.

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(2 marks)

6 (a) (iv) Suggest what is meant by magnetic anomalies.

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(1 mark)

6 (b) Use the laws of electromagnetic induction to explain how the alternating current determines the magnitude of the current in the circuit connected to the sensor coil.

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(4 marks)

Question 6 continues on the next page

Turn over ▶

6 (c) The maximum rate of change of flux through the sensor coil is 3.3×10^{-9} Wb s^{-1}.
The sensor coil has 200 turns and a resistance of 5.2 Ω.

6 (c) (i) Calculate the maximum emf induced in the sensor coil.

maximum emf V
(2 marks)

6 (c) (ii) Calculate, in μA, the maximum current in the sensor coil.

maximum current .... μA
(2 marks)

6 (c) (iii) List two changes to the magnetometer which would increase its sensitivity when measuring external magnetic fields.

change 1 ....

change 2 ....
(2 marks)

16

END OF QUESTIONS

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