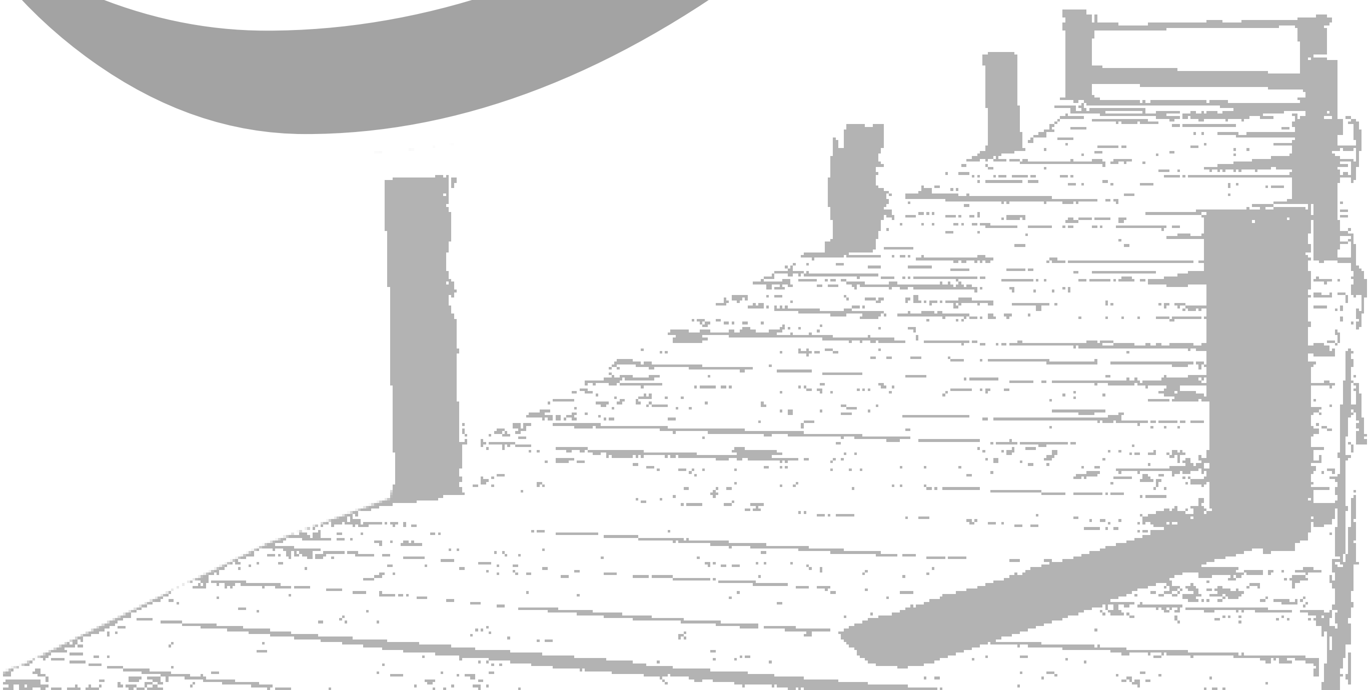
GCE
AS and A Level

Physics B: Physics In Context

AS exams 2009 onwards
A2 exams 2010 onwards

Unit 4: Approved specimen question paper

Version 1.3



Surname		Other Names	
Centre Number		Candidate Number	
Candidate Signature			

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General Certificate of Education
2009
Advanced Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

version 1.3 (amended 26/1/10)

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

SPECIMEN PAPER

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

Time allowed: 1 ¾ hours

Instructions
- Use blue or black ink or ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- A *Formulae and Data Booklet* is provided as a loose insert.

Information
- The maximum mark for this paper is 100.
- The marks for the questions are shown in brackets.
- You are reminded of the need for good English and clear presentation in your answers. You will be assessed on your quality of written communication where indicated in the question.

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

1 A satellite is placed in orbit around the Earth at an orbital radius of 4.3×10^7 m. The gravitational field strength at 4.3×10^7m from the centre of the Earth is 0.23 N m^{-1}.

(a) (i) Show that the orbital period of this satellite is about 24 hours.

(ii) The satellite is to be placed in a geostationary orbit. Explain what this means and give **one** use for such a satellite.

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(6 marks)

(b) The speed of the satellite in orbit needs to be changed by 2.3 m s^{-1} as part of the manoeuvre to make the orbit geostationary. Fuel is ejected from the satellite at 95 m s^{-1} to accomplish this.
If the final mass of the satellite after the gas ejection is 1800 kg, show that about 44 kg of gas needs to be ejected.

(4 marks)

(c) (i) Dust particles collide with the satellite. A dust particle has a mass of 1.2×10^{-4} kg and a speed, relative to the satellite, of 58 km s^{-1}. The collision takes 1.4 ms.

Calculate the resistive force acting on the satellite as a result of this collision. Assume that the dust particle was initially travelling in the opposite direction to the satellite and after the collision is imbedded in the satellite.

(ii) Suggest what effect these dust particle collisions will have on the motion of the satellite.

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(6 marks)

(d) One possible use for the satellite is to store high level radioactive waste from nuclear reactors. Some of the factors used in deciding for and against this proposal include:

- protection of the radioactive material
- possibility of complete removal of the material from Earth
- cost issues

Discuss this proposal for the satellite usage using these and any other relevant points. Make clear your own position on the argument.

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

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(6 marks)

Total 22 Marks

2 (a) The moment of inertia I of a body can be defined using the equation.

$$I = \frac{T}{\alpha}$$

State the meaning of the symbols T and α.

	meaning
T	
α	

(2 marks)

(b) A fairground ride spins the passengers around a circle of radius 5.0 m.
The maximum centripetal acceleration allowed for a human on the ride is 50 m s^{-2}.

(i) Show that the maximum safe angular speed of the ride is about 3 rad s^{-1}.

(ii) The ride starts to rotate from rest and the maximum angular acceleration allowed during this start-up phase is 0.6 rad s^{-2}.
Calculate the minimum safe time to reach this speed.

(iii) The moment of inertia of the ride when it is fully loaded is 4.3×10^5 kg m^{-2}.
Calculate the torque required to accelerate the ride.

(9 marks)

(c) The ride designer intends to use enclosed capsules for the ride. Discuss the advantages and disadvantages of using open seating for the passengers rather than an enclosed capsule.

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(4 marks)

Total 15 marks

3 (a) Give **two** examples of the techniques used by geologists to obtain values of the strength of the local gravitational field of the Earth.
In each of your quoted examples, describe the information that the geologists can derive from their measurements.

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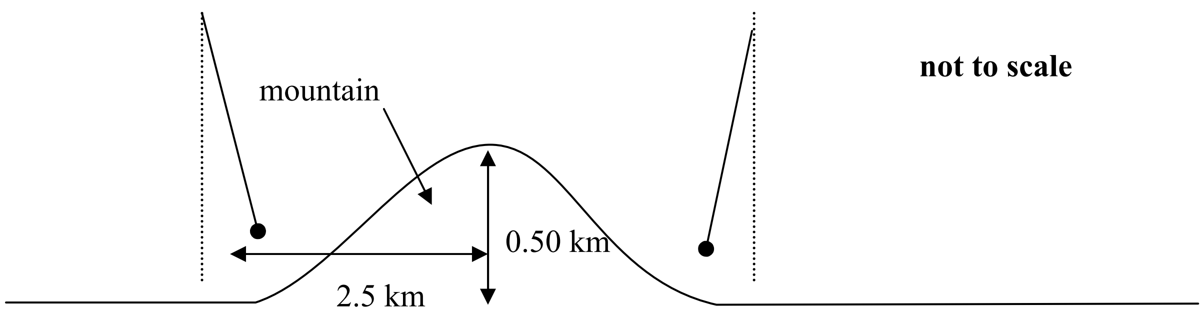
(4 marks)

In 1774, Nevil Maskelyne carried out an experiment near the mountain of Schiehallion in Scotland to determine the density of the Earth.

Figure 1 shows two positions of a pendulum hung near to, but on opposite sides of, the mountain. The centre of mass of the mountain is at the same height as the pendulum.

Figure 1



(b) (i) Explain why the pendulums do not point towards the centre of the Earth.

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(ii) Suggest why Maskelyne carried out the experiment on both sides of the mountain.

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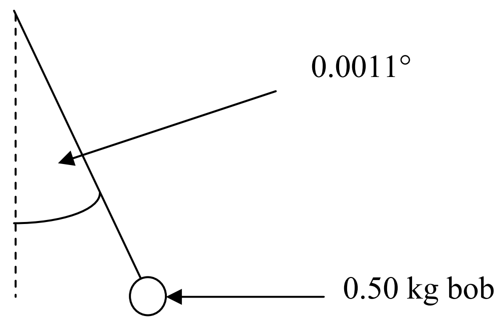
(3 marks)

(c) **Figure 2** shows measurements made with the left-hand pendulum in **Figure 1**.

Figure 2



(i) The mountain is in the appropriate shape of a cone 0.50 km high and 1.3 km base radius; it rises from a locally flat plain.
Show that the mass of the mountain is about 2×10^{12} kg.

volume of a cone = $\frac{1}{3}\pi r^2 h$

density of rock = 2.5×10^3 kg m^{-3}

(ii) **Figure 2** shows the left-hand pendulum bob lying on a horizontal line that also passes through the centre of mass of the mountain. The bob is 1.4 km from the centre of the mountain and it hangs at an angle of 0.0011° to the vertical.

Calculate the mass of the Earth.

(iii) The answer Maskelyne obtained for the mass of the Earth was lower than today's accepted value even though he had an accurate value for the Earth's radius.
Suggest **one** reason why this should be so.

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(7 marks)

Total 14 marks

4 (a) Explain the physical principles behind the operation of a magnetic resonance imaging (MRI) scanner used in medical diagnosis. In your answer you should include an explanation of the meaning of the term *precession*.

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(5 marks)

(b) Patients are normally required to remove metallic objects before being MRI scanned.

A patient in a scanner is still wearing a metal ring of radius 8.0 mm. The magnetic field in the scanner is 0.40 T.

(i) Calculate the magnitude of the flux linking the ring when the ring is held perpendicular to the field direction.

(ii) State the unit of magnetic flux linkage.

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(4 marks)

(c) (i) The magnetic field of the scanner is reduced to zero in 0.10 s.

Calculate the maximum emf that can be induced in the ring.

(ii) A ring with a different radius would have a different emf.
State and explain **two** other ways in which the emf of the ring would be **halved**.

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(6 marks)

Total 15 marks

5 **Figure 3** shows an X-ray spectrum produced by the medical X-ray machine shown in **Figure 4** that is operating at an accelerating potential of 40 kV. Use the information in these figures and the data sheet to answer this question.

Figure 3

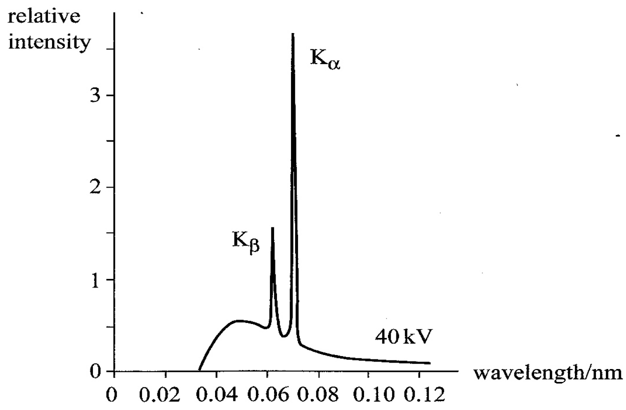
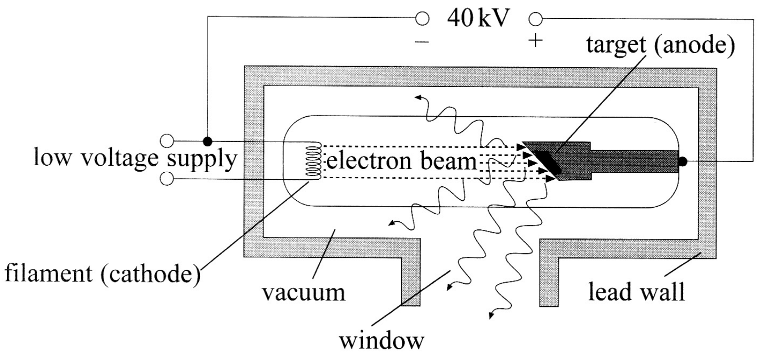


Figure 4



(a) (i) Use **Figure 3** to estimate the highest frequency of the X-rays emitted by the tube.

(ii) Calculate the maximum velocity of the electrons when this tube operates at 40 kV. State any assumption you make.

Assumption ....

(6 marks)

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(b) Explain how the characteristic X-ray lines K_α and K_β in **Figure 3** are produced.

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(3 marks)

(c) (i) Explain why the electrons need to be accelerated in a vacuum.

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(ii) Explain why the metal target in the X-ray tube needs to be cooled.

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(iii) Explain why water is used as a coolant.

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(5 marks)

Total 14 marks

6 (a) (i) Explain what is meant by the spring constant k of a spring.

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(ii) Give the unit of k.

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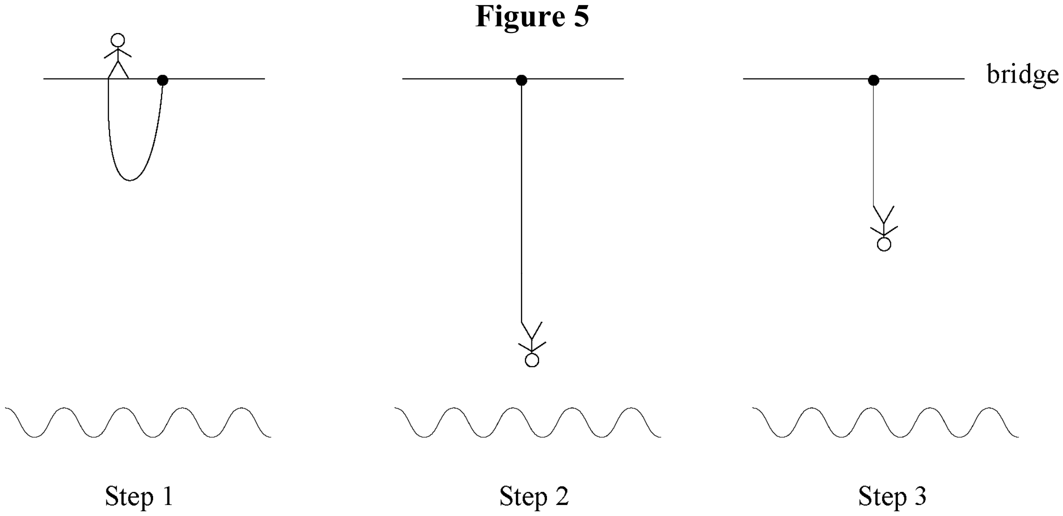
(2 marks)

(b) **Figure 5** shows the stages in a bungee jump.

Figure 5



In bungee jumping, the participant jumps from a high point attached to an elastic cord (step 1). After a period of free fall, the cord slows the fall of the jumper (step 2) with the system eventually undergoing oscillation (step 3).
A bungee jump is to be set up from a suspension bridge with the jumper of weight 700 N falling towards the river below. The roadway of the bridge is 76 m above the river surface. The bungee cord is adjusted so that the jumper just reaches the river surface at the bottom of the first oscillation.

The unstretched length of the elastic cord is to be 12 m.

(i) Calculate the time taken before the cord begins to stretch.

(ii) Show that, when jumping from the bridge to the river, the jumper loses about 53 kJ of gravitational potential energy.

(iii) Calculate the extension of the cord when the jumper is at the bottom of the first oscillation.

(iv) The gravitational potential energy is stored in the bungee cord.
Calculate the spring constant of the cord.

(v) Calculate the time period of oscillation of the jumper.

(12 marks)

(c) (i) Calculate the tension in the cord when the jumper comes to rest for the first time.

(ii) Forces on astronauts and 'thrill seekers' are often specified in terms of the *g* force acting on the participants.

1*g* is equivalent to an acceleration of 9.8 m s^{-2}.

Calculate the maximum *g* force that acts on the jumper.

(iii) Hardened thrill seekers prefer their sports to generate 3*g* or more. Without carrying out detailed calculations, suggest the changes that would need to be made to the cord in order to produce a greater *g* force for the 700 N jumper.

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(6 marks)

Total 20 marks