

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced GCE

PHYSICS A

2824

Forces, Fields and Energy

Thursday

16 JUNE 2005

Morning

1 hour 30 minutes

Candidates answer on the question paper.

Additional materials:

Electronic calculator

Candidate Name	Centre Number	Candidate Number											
	<table border="1" style="display: inline-table; border-collapse: collapse;"> <tr> <td style="width: 20px; height: 20px;"></td> <td style="width: 20px; height: 20px;"></td> <td style="width: 20px; height: 20px;"></td> <td style="width: 20px; height: 20px;"></td> <td style="width: 20px; height: 20px;"></td> <td style="width: 20px; height: 20px;"></td> </tr> </table>							<table border="1" style="display: inline-table; border-collapse: collapse;"> <tr> <td style="width: 20px; height: 20px;"></td> <td style="width: 20px; height: 20px;"></td> <td style="width: 20px; height: 20px;"></td> <td style="width: 20px; height: 20px;"></td> <td style="width: 20px; height: 20px;"></td> </tr> </table>					

TIME 1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

- Write your name in the space above.
- Write your Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- Write your answers in the spaces provided on the question paper.
- Read each question carefully and make sure you know what you have to do before starting your answer.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets [] at the end of each question or part question.
- You will be awarded marks for the quality of written communication where this is indicated in the question.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.

FOR EXAMINER'S USE		
Qu.	Max.	Mark
1	12	
2	12	
3	15	
4	10	
5	13	
6	12	
7	16	
TOTAL	90	

This question paper consists of 18 printed pages and 2 blank pages.

Answer **all** the questions.

1 This question is about kicking a football.

- (a)** Fig. 1.1 shows how the force F applied to a ball varies with time t whilst it is being kicked horizontally. The ball is initially at rest.

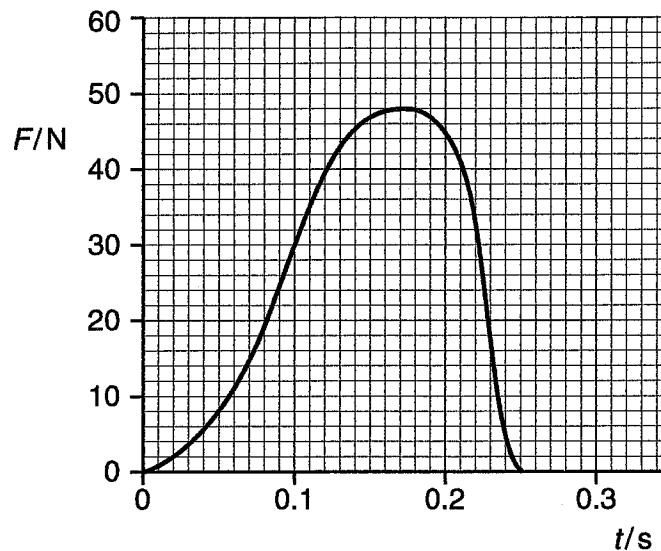


Fig. 1.1

- (i)** Use the graph to find

1 the maximum force applied to the ball

maximum force =N

2 the time the boot is in contact with the ball.

time =s [1]

- (ii)** The mean force multiplied by the time of contact is called the impulse delivered to the ball. Use the graph to estimate the impulse delivered to the ball.

impulse =Ns [2]

(b) The mass of the ball is 0.50 kg. Use your answers to **(a)** to calculate

(i) the maximum acceleration of the ball

acceleration =m s⁻² [2]

(ii) the final speed of the ball

speed =m s⁻¹ [2]

(iii) the kinetic energy of the ball after the kick.

kinetic energy =J [2]

(c) The ball hits a wall with a speed of 14 m s⁻¹. It rebounds from the wall along its initial path with a speed of 8.0 m s⁻¹. The impact lasts for 0.18 s. Calculate the mean force exerted by the ball on the wall.

force =N [3]

[Total: 12]

- 2 (a) Define *gravitational field strength* at a point in a gravitational field.

.....
[1]

- (b) The gravitational field strength at the surface of a planet of uniform density is 40 N kg^{-1} .

A satellite of mass 1500 kg is launched from the surface into a circular orbit around the planet at a height of $1.5 \times 10^5 \text{ m}$ with an orbital period of $4.5 \times 10^3 \text{ s}$.

The radius of the planet is $2.0 \times 10^7 \text{ m}$.

- (i) Estimate the increase in potential energy of the satellite.

potential energy = J [2]

- (ii) Suggest with a reason whether your estimate in (i) is likely to be larger or smaller than the true value.

.....

[1]

- (iii) Calculate the kinetic energy of the satellite in orbit.

kinetic energy = J [4]

- (c) Fig. 2.1 shows how the gravitational field strength g varies with distance r from the centre of the planet of radius $2.0 \times 10^7 \text{ m}$.

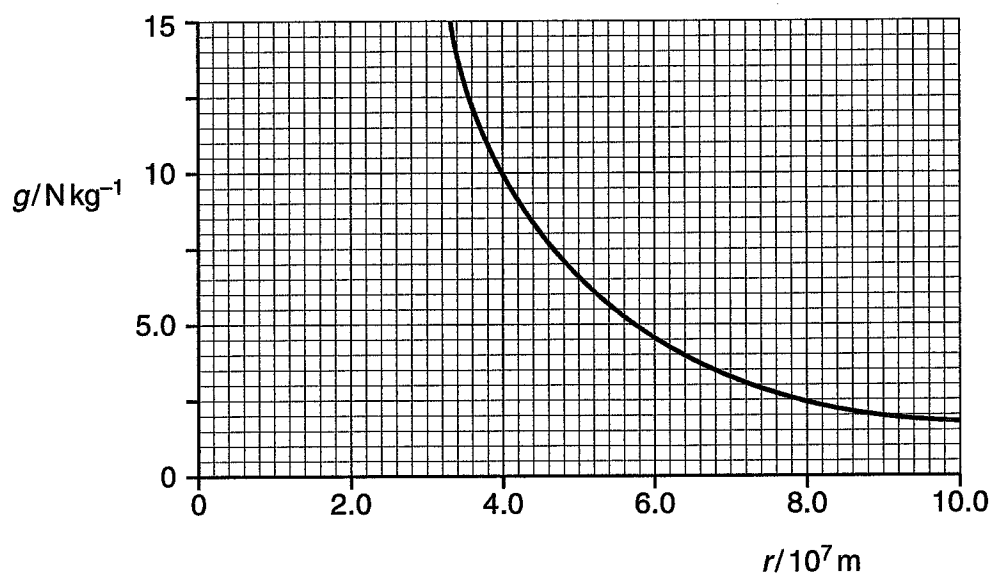


Fig. 2.1

- (i) Use Fig. 2.1 to write down the value of g at a height of $4.0 \times 10^7 \text{ m}$ above the surface.

$$g = \dots\dots\dots \text{N kg}^{-1} \quad [1]$$

- (ii) Write down an algebraic expression for g at a distance r from the centre of the planet. The planet can be treated as a point mass of magnitude M situated at its centre.

.....[1]

- (iii) The value of g at the surface is 40 N kg^{-1} . Use this information and your answer to (ii) to check, by a suitable calculation, your answer to (i).

[2]

[Total: 12]

- 3 (a) The equation of state of an ideal gas is $pV = nRT$. Explain why the temperature must be measured in kelvin.

.....

[2]

- (b) A meteorological balloon rises through the atmosphere until it expands to a volume of $1.0 \times 10^6 \text{ m}^3$, where the pressure is $1.0 \times 10^3 \text{ Pa}$. The temperature also falls from 17°C to -43°C .

The pressure of the atmosphere at the Earth's surface = $1.0 \times 10^5 \text{ Pa}$.

Show that the volume of the balloon at take off is about $1.3 \times 10^4 \text{ m}^3$.

[3]

- (c) The balloon is filled with helium gas of molar mass $4.0 \times 10^{-3} \text{ kg mol}^{-1}$ at 17°C at a pressure of $1.0 \times 10^5 \text{ Pa}$. Calculate

- (i) the number of moles of gas in the balloon

number of moles =[2]

- (ii) the mass of gas in the balloon.

mass =kg [1]

- (d) The internal energy of the helium gas is equal to the random kinetic energy of all of its molecules. When the balloon is filled at ground level at a temperature of 17°C the internal energy is 1900 MJ. Estimate the internal energy of the helium when the balloon has risen to a height where the temperature is -43°C .

internal energy =MJ [2]

- (e) The upward force on the filled balloon at the Earth's surface is $1.3 \times 10^5 \text{ N}$. The initial acceleration of the balloon as it is released is 27 m s^{-2} . The total mass of the filled balloon and its load is M .

- (i) On Fig. 3.1 draw and label suitable arrows to represent the forces acting on the balloon immediately after lift off. [2]

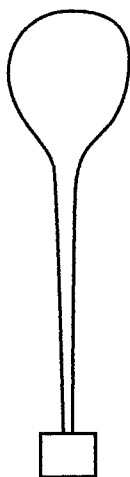


Fig. 3.1

- (ii) Calculate the value of M .

$M = \text{.....kg}$ [3]

[Total: 15]

4 In nuclear fission, energy is released.

(a) Explain what is meant by *nuclear fission*.

.....
.....[1]

(b) In a possible fission reaction $^{235}_{92}\text{U}$ captures a neutron to become a compound nucleus before splitting into $^{141}_{56}\text{Ba}$ and $^{92}_{36}\text{Kr}$ releasing three neutrons.

Write down the nuclear reaction equation for this event.

.....[2]

(c) The total mass of the compound nucleus $^{236}_{92}\text{U}$ before fission is 236.053 u. The total mass of the fission products is 235.867 u. Use these data to calculate the energy released in the fission process.

energy =J [3]

- (d) Most of the energy released arises from the electrostatic repulsion of the two nuclei as they move apart. Use the information in (b) to show that the force F between the two nuclei at the instant after fission occurs is about 3000 N.
Assume the nuclei act as point charges a distance r apart of $1.3 \times 10^{-14} \text{ m}$.

[4]

[Total: 10]

- 5 (a) Define *magnetic flux density*.

.....

[2]

- (b) Fig. 5.1 shows an evacuated circular tube in which charged particles can be accelerated. A uniform magnetic field of flux density B acts in a direction perpendicular to the plane of the tube.

Protons move with a speed v along a circular path within the tube.

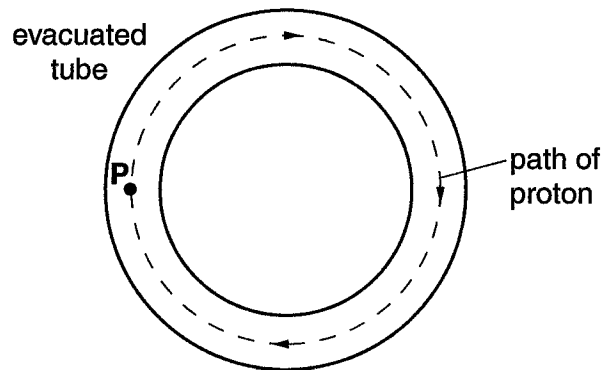


Fig. 5.1

- (i) On Fig. 5.1 draw an arrow at **P** to indicate the direction of the force on the protons for them to move in a circle within the tube. [1]
- (ii) State the direction of the magnetic field. Explain how you arrived at your answer.

.....

[2]

- (iii) Write down an algebraic expression for the force F on a proton in terms of the magnetic field at point **P**.

.....[1]

- (iv) Calculate the value of the flux density B needed to contain protons of speed $1.5 \times 10^7 \text{ m s}^{-1}$ within a tube of radius 60 m. Give a suitable unit for your answer.

$B = \dots\dots\dots \text{unit} \dots\dots\dots$ [5]

- (v) State and explain what action must be taken to contain protons, injected at twice the speed ($2v$), within the tube.

.....
.....
.....
.....[2]

[Total: 13]

- 6 (a) Fig. 6.1 shows a toy consisting of a light plastic aeroplane suspended from a long spring.

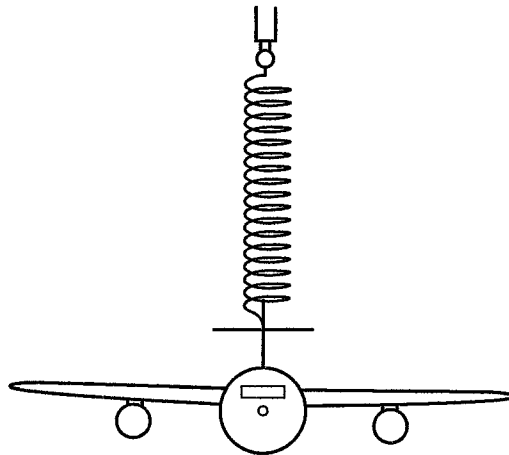


Fig. 6.1

- (i) The aeroplane is pulled down 0.040 m and released. It undergoes a vertical harmonic oscillation with a period of 1.0 s. The oscillations are lightly damped. Sketch on the axes of Fig. 6.2 the displacement y of the aeroplane against time t from the moment of release. [3]

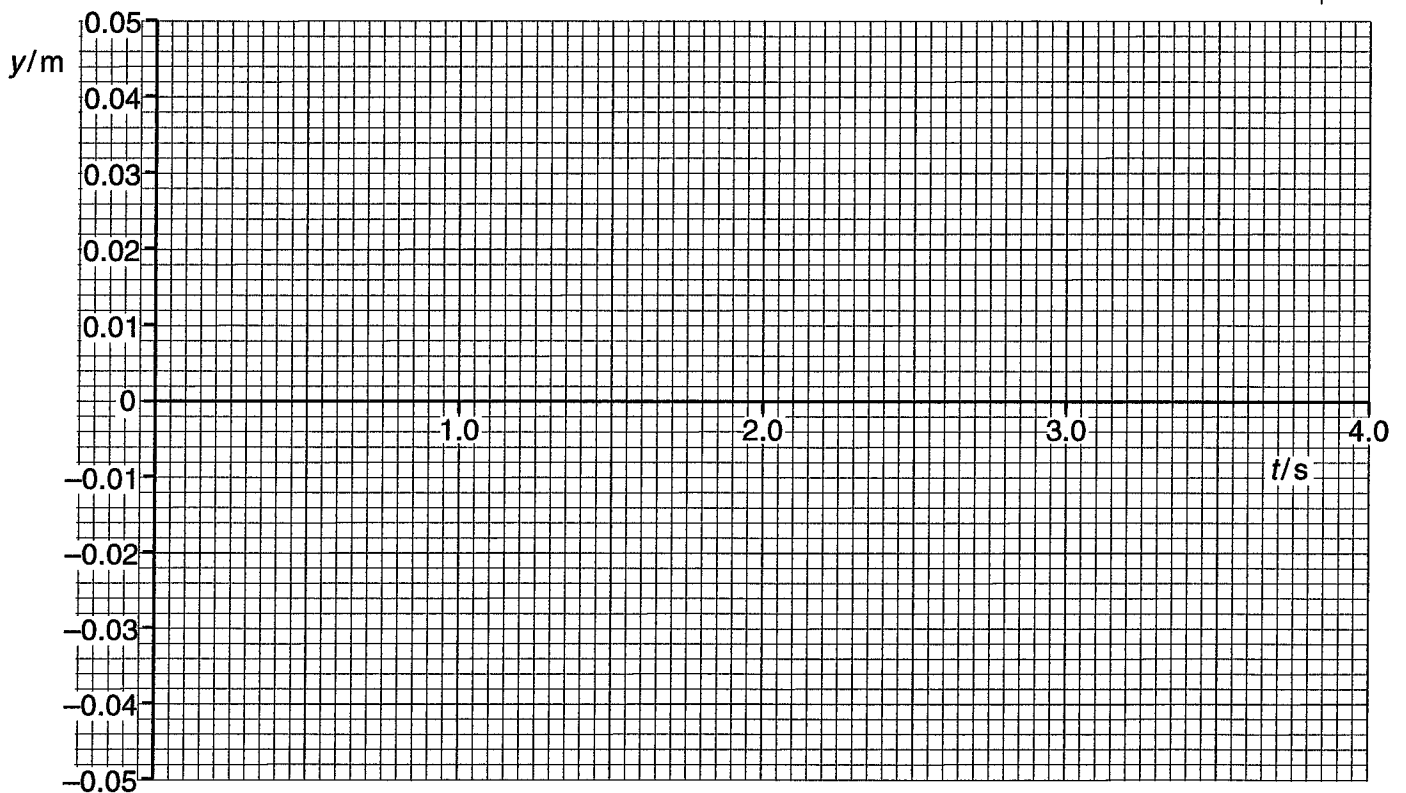


Fig. 6.2

- (ii) The aeroplane is replaced by a heavier model made of the same plastic having the same fuselage but larger wings. State and explain **two** changes which this substitution will make to the displacement against time graph that you have drawn on Fig. 6.2.

.....

.....

.....

.....

.....

.....

.....[4]

- (b) The top end of the spring in Fig. 6.1 is then vibrated vertically with a small constant amplitude. The motion of the aeroplane changes as the frequency of oscillation of the top end of the spring is increased slowly from zero through resonance to 2.0 Hz. Explain the conditions for resonance to occur and describe the changes in the motion of the aeroplane as the frequency changes from zero to 2.0 Hz.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....[5]

[Total: 12]

(a) State and compare the nature and properties of the three types of ionising radiations emitted by naturally occurring radioactive substances.

[6]

- [6]

[Total: 16]

2824 Jun05