OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced Subsidiary GCE

PHYSICS A 2821

Forces and Motion

Wednesday **6 JUNE 2001** Afternoon 1 hour 30 minutes

Candidates answer on the question paper.
Additional materials:
Electronic calculator

Candidate Name	Centre Number	Candidate Number

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 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	14	
2	12	
3	11	
4	8	
5	10	
6	10	
7	11	
8	10	
QWC	4	
Total	90	

This question paper consists of 15 printed pages and 1 blank page.

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Data

speed of light in free space,	$c = 3.00 \times 10^{8}\ \mathrm{m\,s^{-1}}$
permeability of free space,	$\mu_0 = 4\pi \times 10^{-7}\ \mathrm{H\,m^{-1}}$
permittivity of free space,	$\epsilon_0 = 8.85 \times 10^{-12}\ \mathrm{F\,m^{-1}}$
elementary charge,	$e = 1.60 \times 10^{-19}\ \mathrm{C}$
the Planck constant,	$h = 6.63 \times 10^{-34}\ \mathrm{J\,s}$
unified atomic mass constant,	$u = 1.66 \times 10^{-27}\ \mathrm{kg}$
rest mass of electron,	$m_e = 9.11 \times 10^{-31}\ \mathrm{kg}$
rest mass of proton,	$m_p = 1.67 \times 10^{-27}\ \mathrm{kg}$
molar gas constant,	$R = 8.31\ \mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant,	$N_A = 6.02 \times 10^{23}\ \mathrm{mol^{-1}}$
gravitational constant,	$G = 6.67 \times 10^{-11}\ \mathrm{N\,m^2\,kg^{-2}}$
acceleration of free fall,	$g = 9.81\ \mathrm{m\,s^{-2}}$

Formulae

uniformly accelerated motion, $s = ut + \frac{1}{2}at^2$

$v^2 = u^2 + 2as$

refractive index, $n = \frac{1}{\sin C}$

capacitors in series, $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \ldots$

capacitors in parallel, $C = C_1 + C_2 + \ldots$

capacitor discharge, $x = x_0 e^{-t/CR}$

pressure of an ideal gas, $p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$

radioactive decay, $x = x_0 e^{-\lambda t}$

$t_{\frac{1}{2}} = \frac{0.693}{\lambda}$

critical density of matter in the Universe, $\rho_0 = \frac{3H_0^2}{8\pi G}$

relativity factor, $= \sqrt{(1 - \frac{v^2}{c^2})}$

current, $I = nAve$

nuclear radius, $r = r_0 A^{1/3}$

sound intensity level, $= 10 \lg \left(\frac{I}{I_0}\right)$

Answer **all** questions.

1 **(a)** **(i)** Define speed.....[1]

(ii) Distinguish between speed and velocity.

.....

.....[2]

(b) Use the equations given below, which represent uniformly accelerated motion in a straight line, to obtain an expression for v in terms of u, a and s only.

$v = u + at$

$s = (u + v)t/2$

[2]

(c) Fig. 1.1 shows a ball kicked from the top of a cliff with a horizontal velocity of 5.6 m s^{-1}. Air resistance can be neglected.

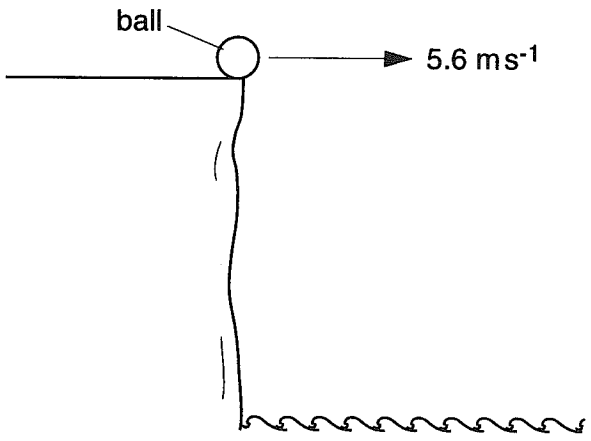

Fig. 1.1

(i) Show that after 0.90 s the vertical component of the velocity is 8.8 m s^{-1}.

[2]

(ii) Use a vector triangle to determine the resultant velocity of the ball after 0.90 s.

resultant velocity: magnitude = ... $m\,s^{-1}$

angle to the horizontal = ... ° [4]

(iii) Calculate

1. the vertical distance the ball falls in 0.90 s,

2. the horizontal distance the ball travels in this time.

1. vertical distance = ... m

2. horizontal distance = ... m [3]

2 Fig. 2.1 shows a trolley of mass 0.80 kg, on a bench surface, connected to a mass M by a string. The mass M is released and the trolley moves along the surface. Fig. 2.2 shows the variation of the velocity v of the trolley with time t for the motion from A to B.

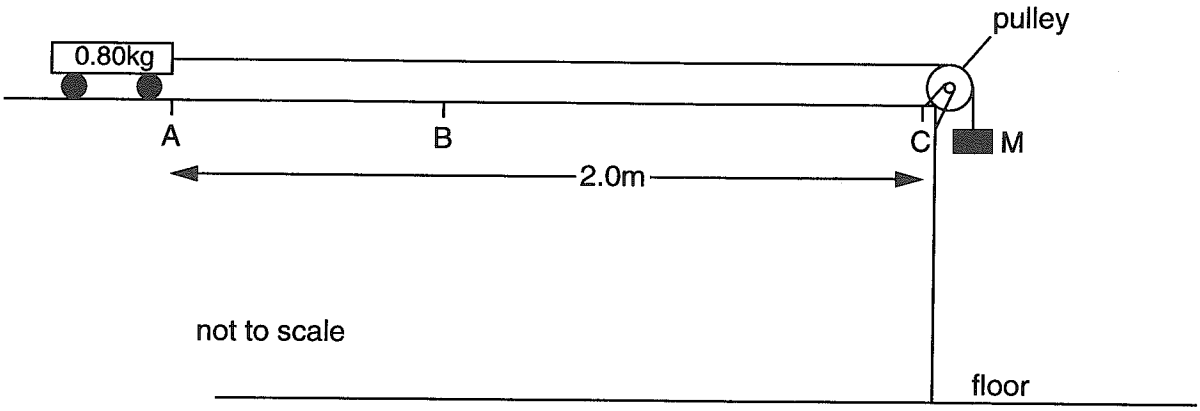

Fig. 2.1

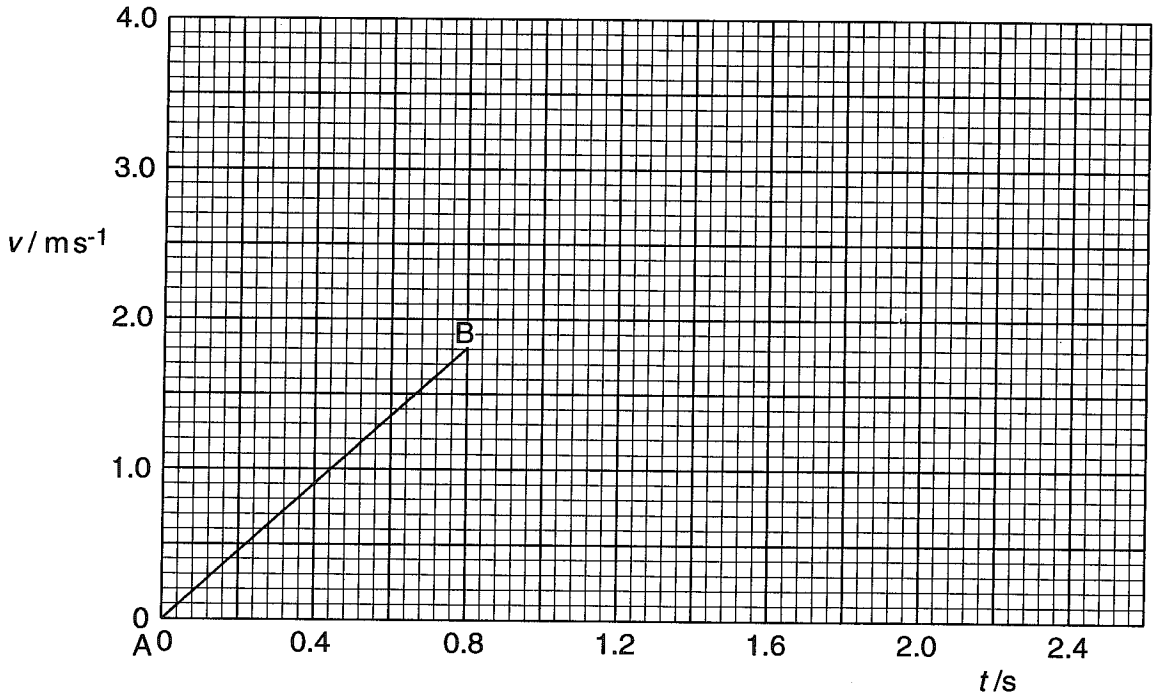

Fig. 2.2

(a) (i) Calculate the acceleration of the trolley between A and B.

acceleration = ... $m\,s^{-2}$ [2]

(ii) Calculate the resultant force acting on the trolley between A and B.

force = ... N [2]

(iii) Show that the distance from A to B is 0.72 m.

[2]

(b) When the trolley reaches B the mass M has just reached the floor.

(i) Ignoring any resistive forces, calculate the time it takes the trolley to travel from B to C.

time for B to C = ... s [3]

(ii) On Fig. 2.2, complete the graph for the trolley moving from B and coming to rest at the pulley at C. [3]

3 **(a)** Use the relation between force, mass and acceleration to express the newton in terms of the SI units of mass, length and time.

.....

.....[1]

(b) Fig. 3.1 shows a garden roller, of mass 80 kg, being pulled with a force of 250 N at an angle of 30° to the horizontal. The roller moves at a constant velocity.

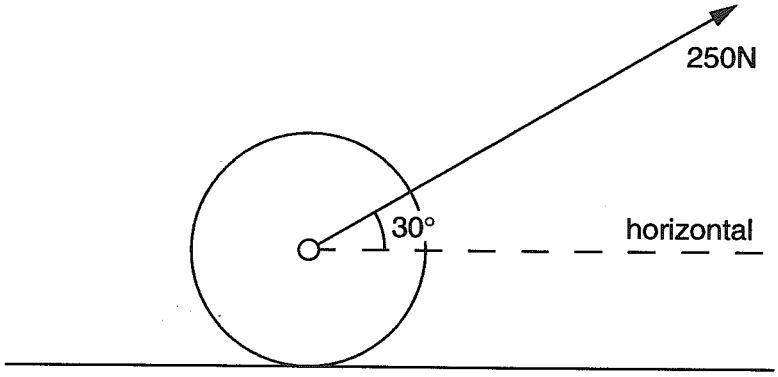

Fig. 3.1

(i) Calculate the weight of the roller.

weight = ... N [1]

(ii) Calculate the magnitude of the horizontal component of the force pulling the roller.

horizontal force = ... N [2]

(iii) Calculate the magnitude of the vertical force exerted by the roller on the ground.

vertical force = ... N [3]

(c) **(i)** Explain how the roller in **(b)** is able to travel at a constant velocity when being pulled by a force of 250 N.

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.....[2]

(ii) The roller is now pushed with a force of 250 N at 30° to the horizontal. State and explain the change that occurs to the force exerted on the ground by the roller. A numerical answer is not required.

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.....[2]

4 **(a)** **(i)** Explain the concept of work and relate it to power.

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.....[2]

(ii) Define the joule.

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.....[1]

(b) A cable car is used to carry people up a mountain. The mass of the car is 2000 kg and it carries 80 people, of average mass 60 kg. The vertical height travelled is 900 m and the time taken is 5 minutes.

(i) Calculate the gain in gravitational potential energy of the 80 people in the car.

gravitational potential energy gain = ... J [2]

(ii) Calculate the minimum power required by a motor to lift the cable car and its passengers to the top of the mountain.

power = ... unit ..... [3]

5 **(a)** **(i)** Define the moment of a force.

.....[1]

(ii) State the principle of moments.

.....

.....[2]

(b) Fig. 5.1 shows a pillar (lying horizontally) made of two uniform sections X and Y each of cross-sectional area 3.5×10^{-2} m^2. The sections are made from two different materials. The weights of X and Y are shown acting through the centre of gravity of each section.

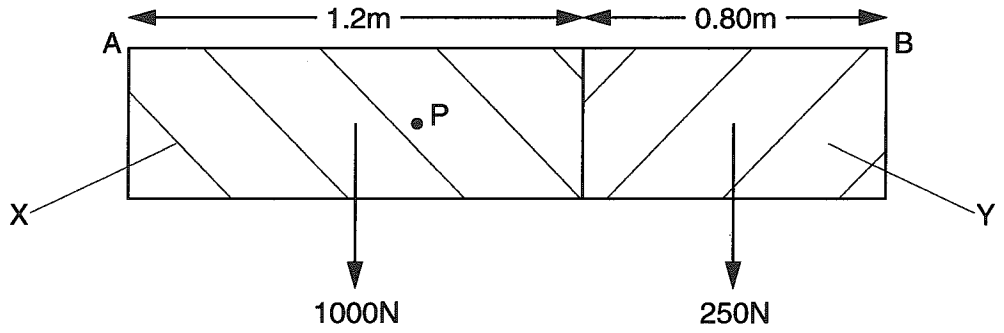

Fig. 5.1

Show that the average density of the pillar is about 1800 kg m^{-3}.

[3]

(c) The pillar in **(b)** will balance horizontally when supported vertically below the point P.

(i) Show, using the principle of moments, that the point P is 1.2 m from the end B.

[3]

(ii) State the significance of the point P.

.....[1]

[Turn over

6 **(a)** State Hooke's Law.

.....

.....[1]

(b) A spring is compressed by applying a force. Fig. 6.1 shows the variation of the force F with compression x.

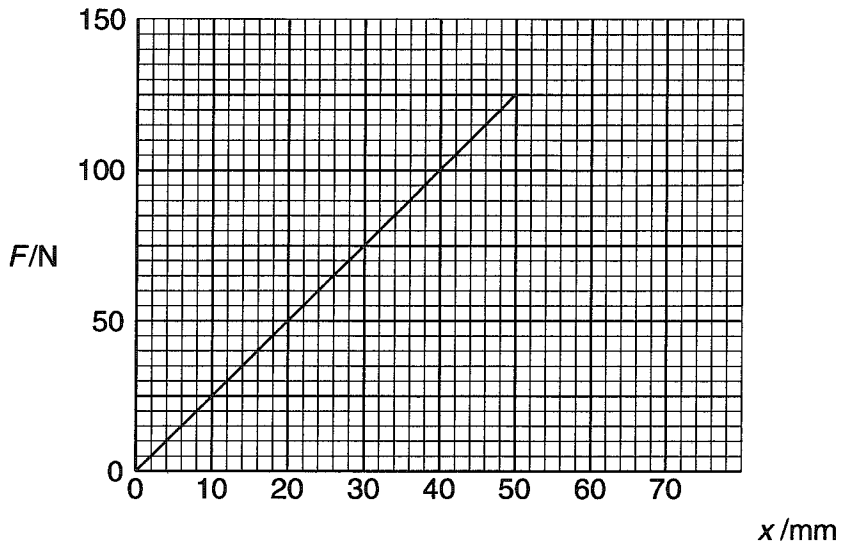

Fig. 6.1

(i) Calculate the spring constant.

spring constant = ... unit ..... [2]

(ii) Show that the work done in compressing the spring by 48 mm is 2.9 J.

[2]

(c) Fig. 6.2 shows the spring in a toy gun. The spring is used to fire a dart of mass 15 g vertically.

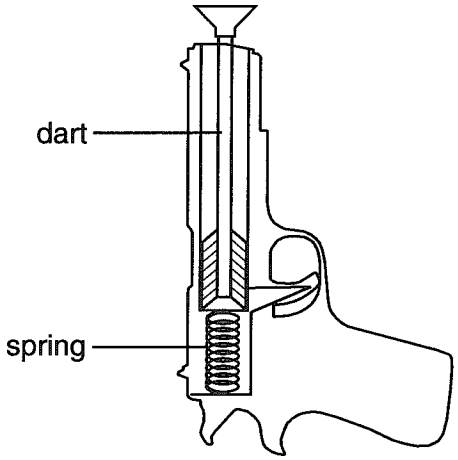

Fig. 6.2

(i) The spring is compressed by 48 mm in the gun. When the gun is fired the strain energy in the spring is converted into the kinetic energy of the dart. Calculate the speed with which the dart initially leaves the spring when the gun is fired.

speed = ... $m\,s^{-1}$ [3]

(ii) Give two reasons why the dart is unlikely to have 2.9 J of gravitational potential energy when it reaches its maximum height.

1. .....

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2. .....

.....[2]

7 **(a)** **(i)** Define the Young modulus of a material.

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.....[2]

(ii) Define elastic limit.

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.....[2]

(iii) Distinguish between elastic and plastic deformation of a material.

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.....[2]

(b) Fig. 7.1 shows graphs of force *F* against extension *x* for three different types of material. Identify with a reason the type of material corresponding to each graph.
(In this question marks are available for the quality of written communication.)

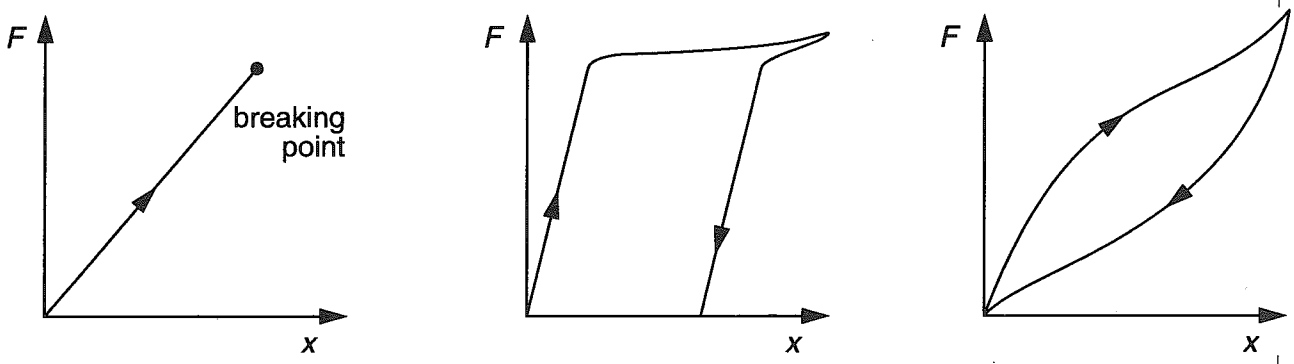

Fig. 7.1

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.....[5]

(In this question marks are available for the quality of written communication.)

8 **(a)** Describe the physical principles of seat belts, air bags and crumple zones as design features of cars used to protect the driver from injury during a collision.

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.....[5]

(b) Explain the term braking distance in relation to the motion of a road vehicle and discuss the factors that affect its value.

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.....[5]

QWC [4]

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