OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS
Advanced Subsidiary GCE

PHYSICS A

2821

Forces and Motion

Thursday **12 JANUARY 2006** Morning 1 hour

Candidates answer on the question paper.
Additional materials:
Electronic calculator
Ruler (cm/mm)
Protractor

Candidate Name

Centre Number

Candidate Number

TIME 1 hour

INSTRUCTIONS TO CANDIDATES

- Write your name, Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- Write your answers, in blue or black ink, in the spaces provided on the question paper.
- Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure you know what you have to do before starting your answer.
- Do not write in the bar code. Do not write in the grey area between the pages.
- **DO NOT** WRITE IN THE AREA **OUTSIDE** THE BOX BORDERING EACH PAGE. ANY WRITING IN THIS AREA WILL NOT BE MARKED.

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	10	
2	10	
3	10	
4	12	
5	8	
6	10	
TOTAL	60	

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

SP (SC/CGW) S87702/6

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[Turn over

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,	$n = \dfrac{1}{\sin C}$
capacitors in series,	$\dfrac{1}{C} = \dfrac{1}{C_1} + \dfrac{1}{C_2} + \ldots$
capacitors in parallel,	$C = C_1 + C_2 + \ldots$
capacitor discharge,	$x = x_0 e^{-t/CR}$
pressure of an ideal gas,	$p = \frac{1}{3}\dfrac{Nm}{V}<c^2>$
radioactive decay,	$x = x_0 e^{-\lambda t}$
	$t_{\frac{1}{2}} = \dfrac{0.693}{\lambda}$
critical density of matter in the Universe,	$\rho_0 = \dfrac{3{H_0}^2}{8\pi G}$
relativity factor,	$= \sqrt{(1 - \dfrac{v^2}{c^2})}$
current,	$I = nAve$
nuclear radius,	$r = r_0 A^{1/3}$
sound intensity level,	$= 10 \lg \left(\dfrac{I}{I_0}\right)$

Answer **all** the questions.

1 Fig. 1.1 illustrates a conveyor belt for transporting young children up a snow-covered bank so that they can ski back down.

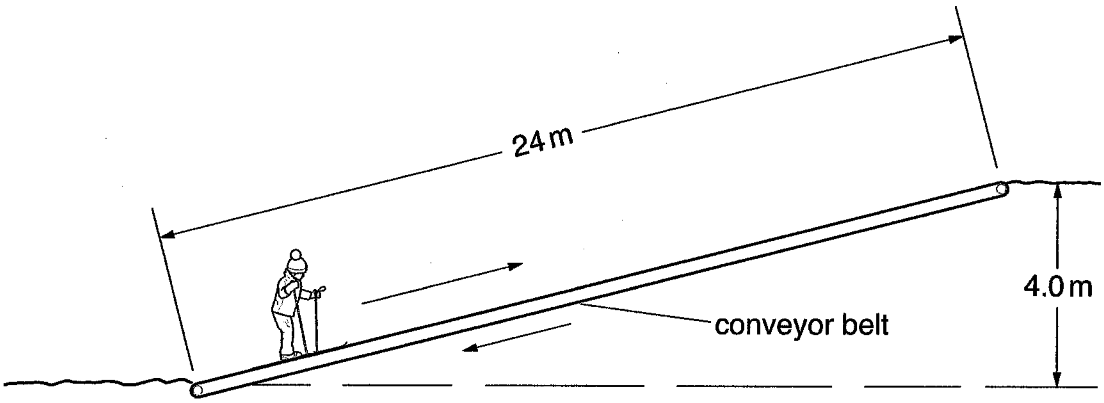

Fig. 1.1

A child of mass 20 kg travels up the conveyor belt at a constant speed. The distance travelled up the slope is 24 m and the time taken is 55 s. The vertical height climbed in this time is 4.0 m.

(a) For the child on the conveyor belt, calculate

(i) her speed

speed = ... m s^{-1} [2]

(ii) her kinetic energy

kinetic energy = ... J [2]

(iii) the increase in her potential energy for the complete journey up the slope.

potential energy = ... J [2]

(b) **(i)** The conveyor belt is designed to take a maximum of 15 children at any one time. Calculate the power needed to lift 15 children of average mass 20 kg through a height of 4.0 m in 55 s.

power = ... W [2]

(ii) The belt is driven by an electric motor. State **two** reasons why the motor needs a greater output power than that calculated in **(b)(i)**.

....

....

....

....[2]

[Total: 10]

2 **(a)** **(i)** Define *velocity*.

....

....[1]

(ii) Define *acceleration*.

....

....[1]

(b) Fig. 2.1 shows a ruler clamped at one end. A mass **M** is attached to the other end of the ruler and is then made to oscillate up and down.

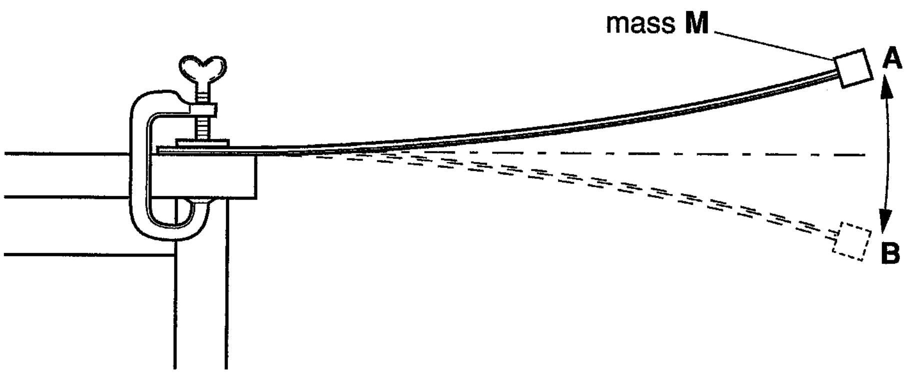

Fig. 2.1

Fig. 2.2 shows the variation with time *t* of the velocity *v* of the mass **M** as it oscillates from **A** to **B** and back to **A**.

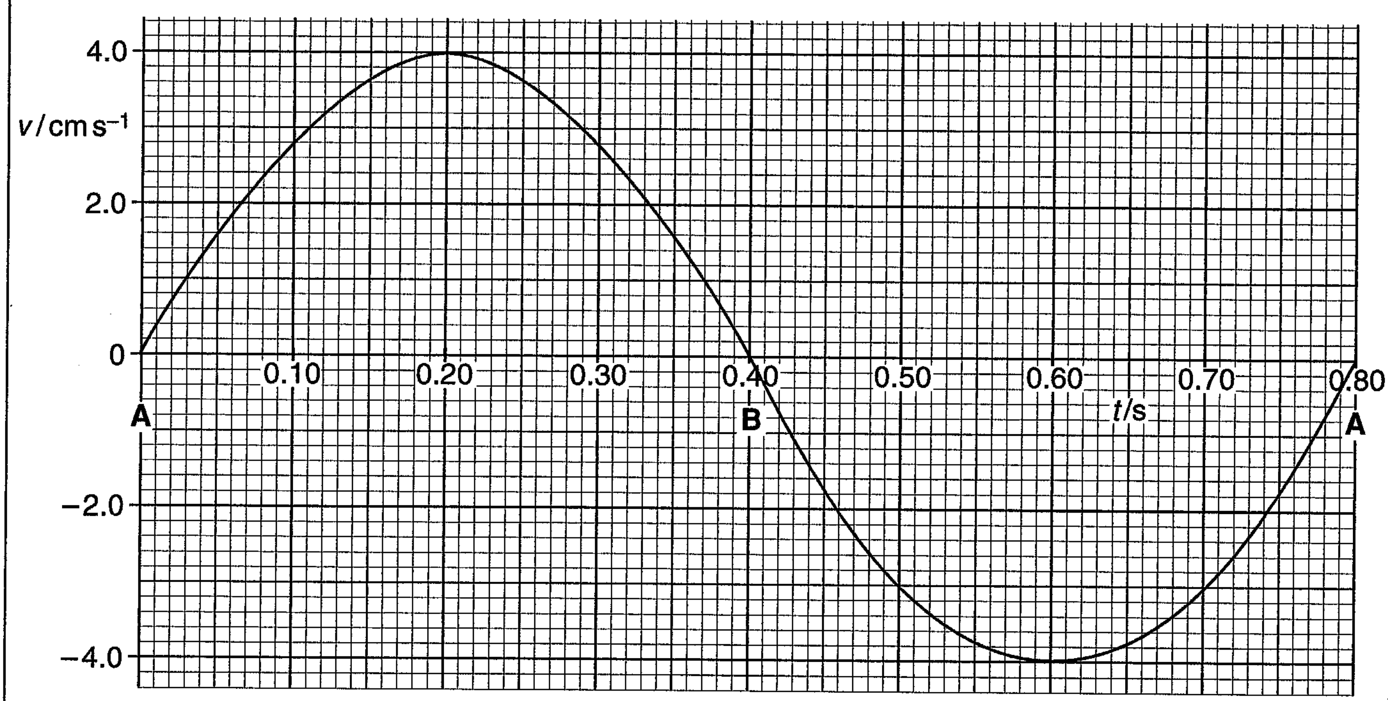

Fig. 2.2

(i) For the graph shown in Fig. 2.2, state what is represented by

1 the area between the graph and the time axis

....[1]

2 the gradient of the graph at a particular time.

....[1]

(ii) Use Fig. 2.2 to determine the distance travelled by the mass **M** from time $t = 0$ to time $t = 0.20$ s.

distance = ... cm [2]

(iii) Use Fig. 2.2 to describe how the acceleration of the mass **M** varies as the mass moves from **A** to **B**.

....

....

....

....[2]

(iv) Use Fig. 2.2 to calculate the average acceleration of the mass **M** between $t = 0.25$ s and $t = 0.55$ s.

acceleration = ... cm s^{-2} [2]

[Total: 10]

3 **(a)** **(i)** Define *pressure*.

....

....[1]

(ii) Define *moment of a force*.

....

....

....[1]

(b) Fig. 3.1 shows a device used for compressing materials.

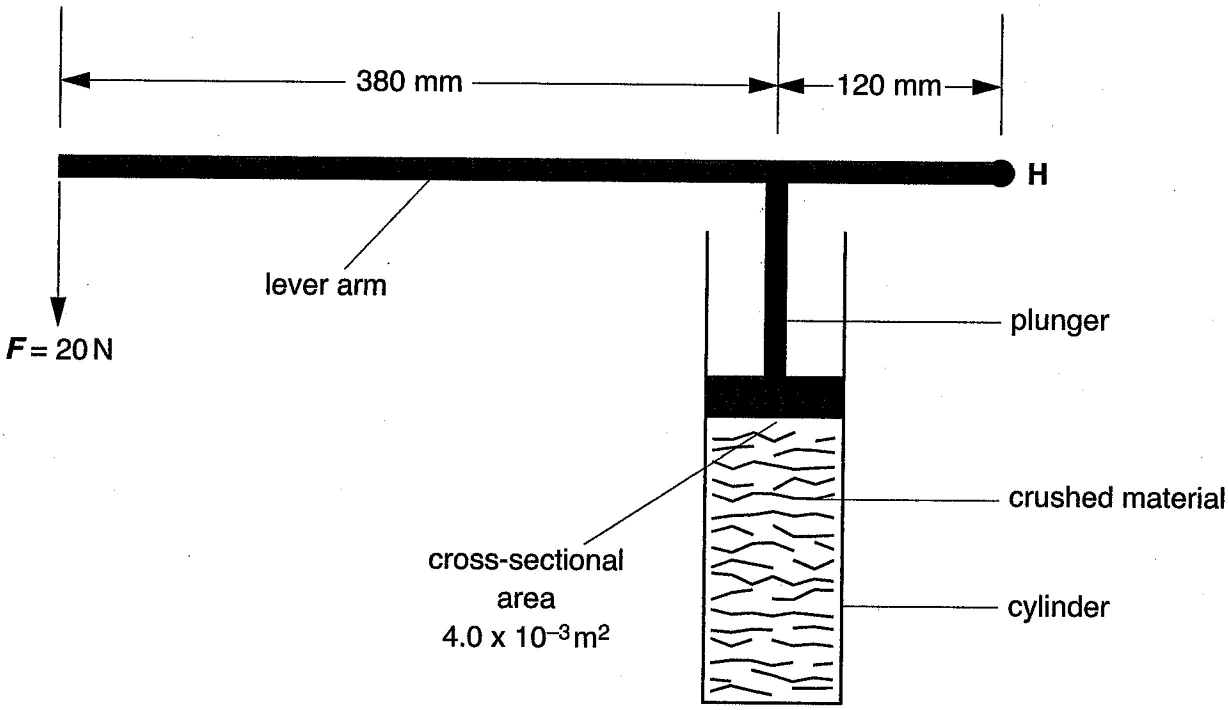

Fig. 3.1

A vertical force ***F*** of 20 N is applied at one end of a lever system. The lever is pivoted about a hinge **H**. The plunger compresses the material in the cylinder.

(i) Two forces acting on the lever arm are its weight and the force ***F***. On Fig. 3.1, draw and label **two** other forces acting on the lever arm. [2]

(ii) By taking moments about **H**, show that the force acting on the plunger is 83 N. The weight of the lever arm may be neglected.

[2]

(c) (i) The cross-sectional area of the plunger is $4.0 \times 10^{-3}\,m^2$. Calculate the pressure exerted by the plunger on the material in the cylinder.

pressure = ... Pa [2]

(ii) State **two** methods of increasing the pressure exerted by the plunger.

....

....

....

....

....[2]

[Total: 10]

4 Fig. 4.1 shows three ropes attached to a ring **R**. Three cylinders **x**, **y** and **z**, are supported by these ropes from two pulleys.

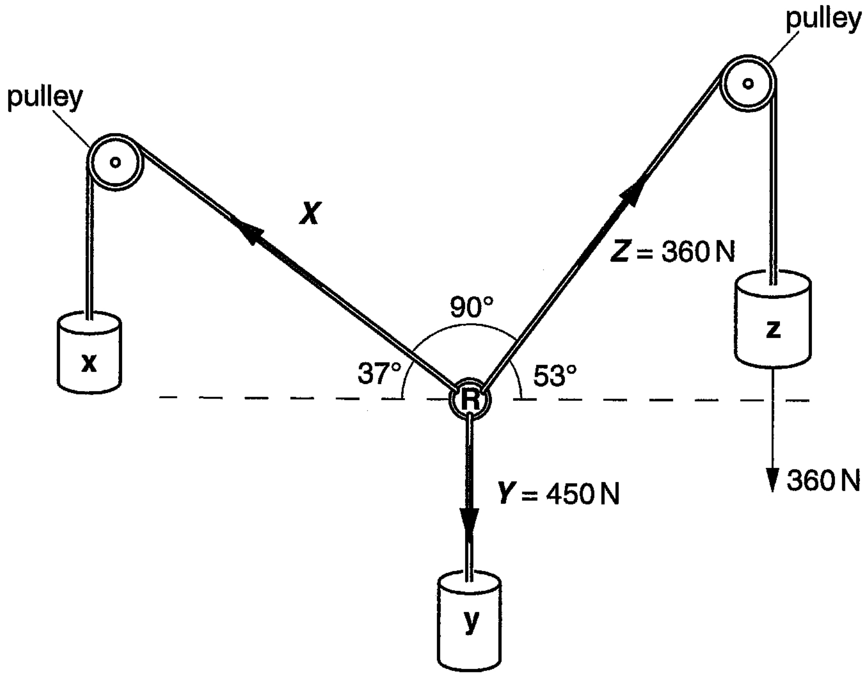

Fig. 4.1

(a) (i) The cylinder **z** has a weight of 360 N and a volume of $4.7 \times 10^{-3}\,m^3$.

Calculate

1 the mass of the cylinder **z**

mass = ... kg [1]

2 the density of the cylinder **z**.

density = ... unit .... [3]

(ii) The ring **R** is in equilibrium. Use a **labelled** vector triangle to determine the tension ***X***.

tension ***X*** = ... N [4]

(b) **(i)** Explain why the sum of the magnitudes of the tensions in any two ropes does not equal the tension in the other rope.

....

....

....[2]

(ii) Show that the sum of the vertical components of the tensions ***X*** and ***Z*** is equal to the tension ***Y***.

[2]

[Total: 12]

5 Fig. 5.1 shows a stress-strain graph up to the point of fracture for a rod of cast iron.

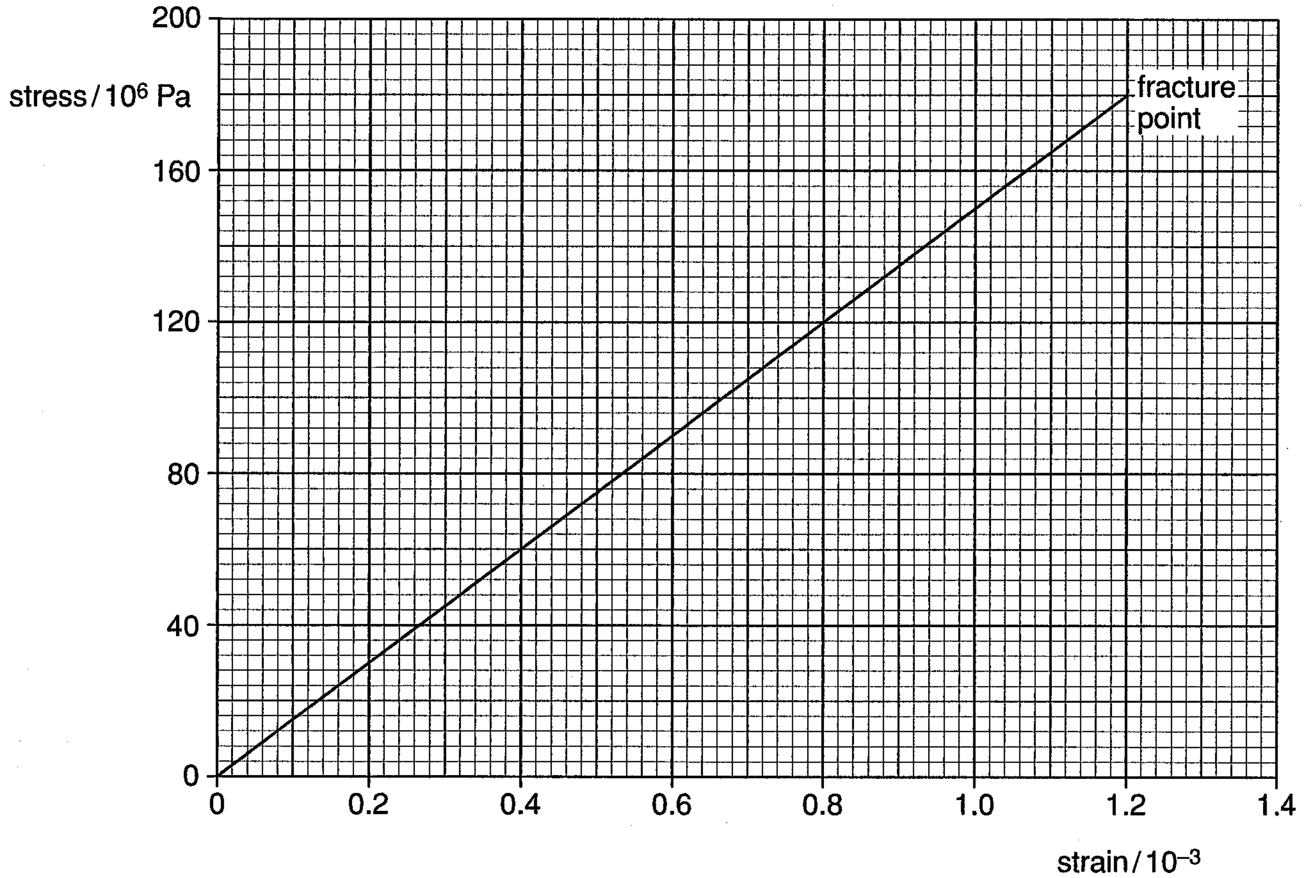

Fig. 5.1

(a) The rod of cast iron has a cross-sectional area of $1.5 \times 10^{-4}\,m^2$.

Calculate

(i) the force applied to the rod at the point of fracture

force = ... N [2]

(ii) the Young modulus of cast iron.

Young modulus .... = N m^{-2} [3]

(b) Use the graph or otherwise to describe the stress-strain behaviour of cast iron up to and including the fracture point.

....

....

....

....

....[3]

[Total: 8]

6 In this question, two marks are available for the quality of written communication.

(a) State and explain **two** factors that affect the braking distance of a car.

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....[4]

(b) State and explain **two** safety features in a car that are designed to protect the driver during a collision.

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....[4]

Quality of Written Communication [2]

[Total: 10]

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