Mr Cowen's answers

OCR
RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE **2821**

PHYSICS A

Forces and Motion

THURSDAY 22 MAY 2008 Afternoon

Time: 1 hour

Candidates answer on the question paper

Additional materials (enclosed): None

Additional materials (required):
Electronic calculator
Ruler (cm/mm)
Protractor

Candidate Forename: Cowen

Candidate Surname: Physics

Centre Number:

Candidate Number:

INSTRUCTIONS TO CANDIDATES

- Write your name in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use blue or black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- Write your answer to each question in the space provided.

INFORMATION FOR CANDIDATES

- The number of marks for each question is given in brackets [ ] at the end of each question or part question.
- The total number of marks for this paper is 60.
- 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	19	
2	8	
3	5	
4	5	
5	9	
6	14	
TOTAL	60	

This document consists of **14** printed pages and **2** blank pages.

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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,	$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \dots$
capacitors in parallel,	$C = C_1 + C_2 + \dots$
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** the questions.

1 (a) (i) State the difference between a scalar and a vector quantity.

Vector has magnitude + direction.
Scalar has magnitude only. [1]

(ii) Underline the vector quantities in the list below.

acceleration density force kinetic energy power volume weight

[2]

(b) Fig. 1.1 shows the path of a ball that is thrown from point **A** to point **B**. The ball reaches its maximum height at point **H**.

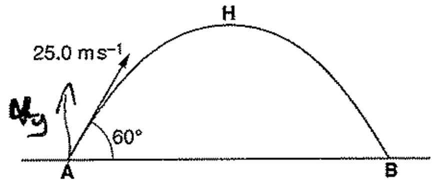


Fig. 1.1

The ball is thrown with an initial velocity of $25.0\,\mathrm{m\,s^{-1}}$ at 60° to the horizontal. Assume that there is no air resistance.

(i) 1 Show that the vertical component of the initial velocity is $21.7\,\mathrm{m\,s^{-1}}$.

$u_y = 25 \sin 60 = 21.7\,\mathrm{ms^{-1}}$

[1]

2 Calculate the time taken for the ball to reach point **H**.

$u_y = 21.7,\ v = 0,\ a = -9.81,\ t = ?$

$v = u + at$

$t = \frac{v-u}{a} = \frac{0 - 21.7}{-9.81} = 2.2$

time = 2.2 s [2]

3 Calculate the displacement from **A** to **B**.

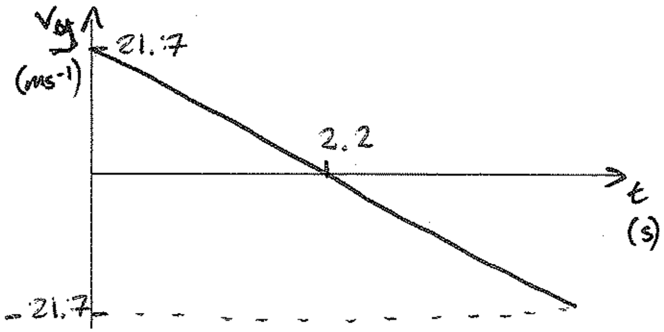
~~W~~ $t = 2.2 \times 2 = 4.4$, $v = 25\cos 60$

$s = vt = 25\cos 60 \times 4.4 = 55$

displacement = 55 m [3]

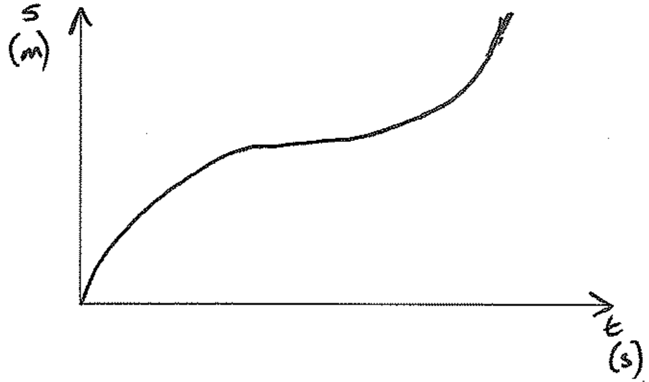
(ii) For the path of the ball shown in Fig. 1.1, draw sketch graphs, with labelled axes but without numerical values, to show the variation of

1 the vertical component of the ball's velocity against time



[3]

2 the distance travelled along its path against time.



[2]

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In this part of the question, one mark is available for the quality of written communication.

(iii) Assuming no air resistance, describe the forms of energy possessed by the ball at **A**, **H** and **B** and how the energy changes between these points.

At A, ball has ~~KE and maximum~~ max KE and min PE. Between A and H, ~~both~~ ~~k~~ KE is transferred to PE. PE is max at H (min KE). PE transfers into KE on way ~~back~~ to B.
KE and PE at point A are equal to at point B.

[4]

Quality of Written Communication [1]

[Total: 19]

2 (a) (i) State the conditions for a system to be in equilibrium.

Resultant force = zero

Sum of clockwise moments = sum of anticlockwise moments [2]

(ii) Define the *moment of a force*.

moment = force × perpendicular distance from the pivot [1]

(b) Fig. 2.1 shows a system for supporting a load.

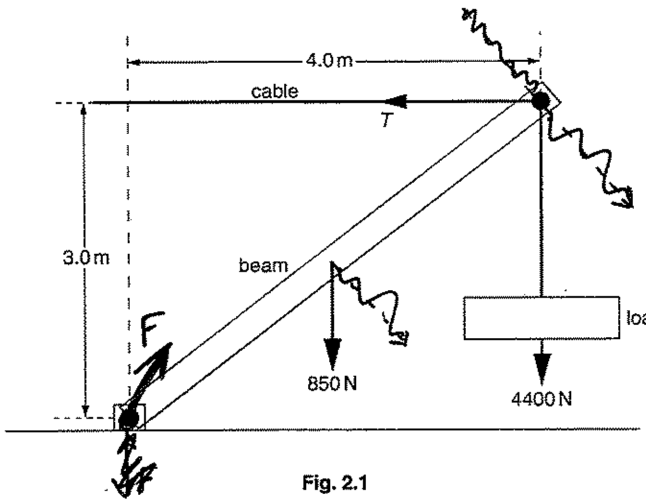

Fig. 2.1

The load of weight 4400 N is hanging from a uniform beam that is supported by a horizontal cable. The beam has a weight of 850 N and is hinged at **A**.

(i) Take moments about **A** and show that the tension T in the cable is 6400 N (to 2 significant figures).

↻ : 850 x 2 + 4400 x 4, ↺ : 3T

↻ = ↺ 850 x 2 + 4400 x 4 = 3T

T = 6400 N

[3]

(ii) State and explain what force, in addition to those shown, must act on the beam to keep it in equilibrium. You are not expected to calculate this force.
Draw this force on Fig. 2.1 and label it **F**.

F is required to give zero resultant force, cancelling out the forces acting down and to the left.

....[2]

[Total: 8]

3 Fig. 3.1 shows a wall built with a material of average density 2500 kg m^{-3}.

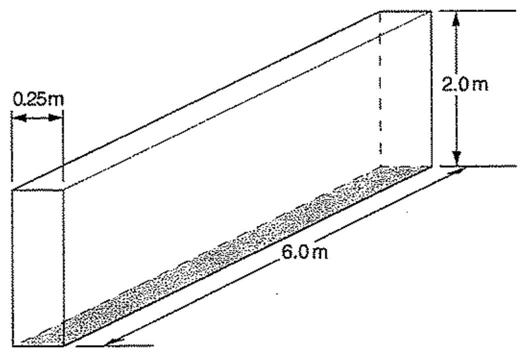

Fig. 3.1

The wall is 6.0 m long, 2.0 m high and 0.25 m wide.

(a) Calculate the mass of the wall.

$V = 2 \times 6 \times 0.25 = 3\,m^3$

$m = \rho V = 2500 \times 3 = 7500\,kg$

mass = 7500 kg [2]

(b) Calculate the pressure the wall exerts on the ground.

$A = 6 \times 0.25 = 1.5\,m^2$

$p = \frac{F}{A} = \frac{mg}{A} = \frac{7500 \times 9.81}{1.5} =$

pressure = 49×10^3 Pa [3]

[Total: 5]

4 Fig. 4.1 shows a method used to knock down walls.

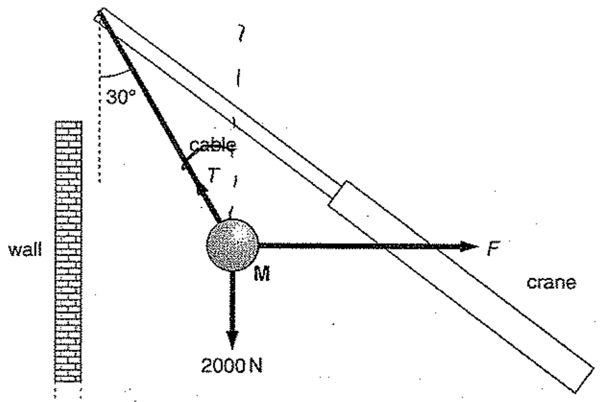

Fig. 4.1

M is a heavy steel ball suspended by a cable in which the tension is T. The ball is pulled to one side by a horizontal force F until the cable is at 30° to the vertical. It is then released so that it swings into the wall. The weight of the ball **M** is 2000 N.

(a) Determine the force F by using a triangle of forces **or** a scale diagram of the forces **or** by resolving forces.

$\updownarrow$: $2000 = T\cos 30°$

$T = \dfrac{2000}{\cos 30} = 2309\,N$

$\leftrightarrow$: $F = T\sin 30°$

$= 2309 \sin 30°$

$F = 1155\ N$

force F = 1155 N [3]

[Turn over

(b) State and explain one change that could be made to this method to cause more damage to the wall.

Increase mass of ball, so it hits the wall with more energy.

[2]

[Total: 5]

5 Fig. 5.1 shows a lorry travelling up a slope.

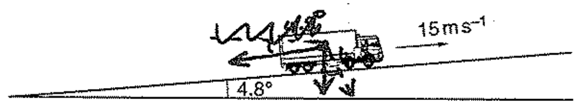

Fig. 5.1

The angle of the slope is 4.8° with the horizontal and the weight of the lorry is 2.4×10^5 N. A resistive force of 1.2×10^4 N down the slope acts on the lorry as it travels up the slope at a constant speed of 15 m s^{-1}.

(a) Show that the component of the weight of the lorry down the slope is 2.0×10^4 N.

Component down slope = $2.4 \times 10^5 \sin(4.8)$

$= 20\,kN$

$= 2.0 \times 10^4\,N$

[1]

(b) Calculate the rate at which the lorry does work against the resistive force.

$W = Fx$

$P = \dfrac{Fx}{t} = Fv = 1.2 \times 10^4 \times 15 = 180000$

rate of work done = 180000 J s^{-1} [2]

(c) Calculate the power developed by the lorry as it travels up the slope.

Net resistive force $= 1.2\times10^4 + 2.0\times10^4 = 3.2\times10^4$

$P = Fv = 3.2\times10^4 \times 15 = 480\,000$

power = 480 000 W [2]

(d) Calculate the rate of gain of potential energy of the lorry.

$V_y = V \sin 4.8^\circ = 15 \sin 4.8$
$= 1.26\ ms^{-1}$

$P = mgV_y = 2.4\times10^5 \times 1.26 = 301\ kW$

rate of gain of potential energy = 301 unit kW [3]

(e) State and explain how the braking distance of the lorry up the slope compares with that on a horizontal road at the same speed.

Braking distance is shorter on the slope because less braking force is needed to slow it down due to the component of weight acting down the slope. [1]

[Total: 9]

[Turn over

6 Fig. 6.1 shows the force F against extension x graph for a copper wire.

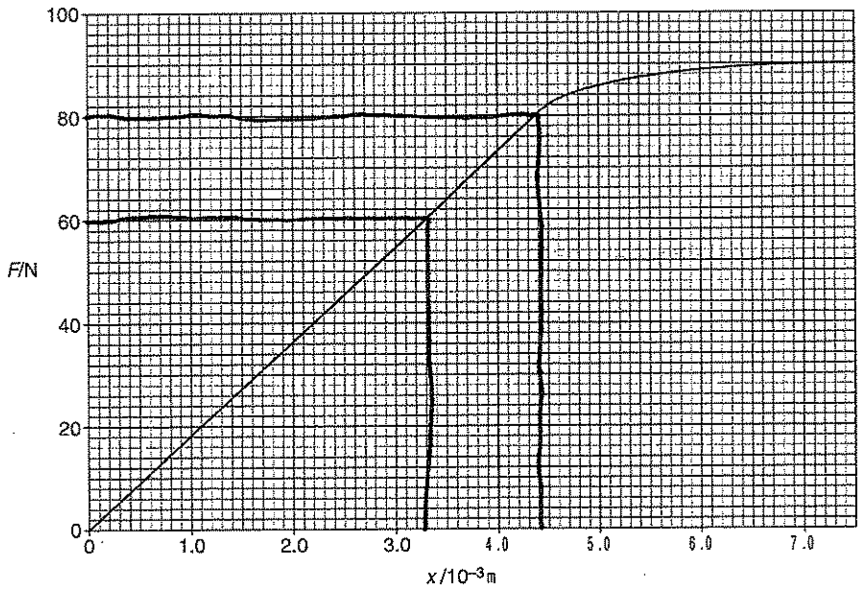

Fig. 6.1

(a) The original length of the wire was 4.0 m and its cross-sectional area $6.3 \times 10^{-7}\,m^2$. Use Fig. 6.1 to calculate

(i) the Young modulus of copper

$\text{stress} = \frac{F}{A} = \frac{60}{6.3\times10^{-7}} = 95\ MPa$

$\text{strain} = \frac{x}{L} = \frac{3.3\times10^{-3}}{4} = 8.25\times10^{-4}$

$\text{Young mod} = \frac{95\times10^6}{8.25\times10^{-4}} = 115\ GPa$

Young modulus = 115 GPa ~~Pa~~ [4]

(ii) the strain energy stored in the wire when it is extended by a force of 80 N.

$E = \frac{1}{2}Fx = \frac{1}{2}80 \times 4.4 \times 10^{-3} =$

strain energy = 0.176 J [2]

(b) The wire is now extended by a force of 90 N. Describe what happens to the extension of the wire when this force is removed.

The wire does not return to its original length, because it has passed the elastic limit. ...[1]

(c) In this part of the question, one mark is available for the quality of written communication.

Describe the behaviour and properties of the copper wire shown by Fig. 6.1 and compare with the behaviour and properties of a stretched glass fibre.

Wire is ductile, glass is brittle.
Wire is elastic in first section, then plastic for larger forces.
Glass is elastic right up to its UTS.

...[6]

Quality of Written Communication [1]

[Total: 14]

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