Mr Cowen's answers

OCR
RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE **2821**

PHYSICS

Forces and Motion

FRIDAY 11 JANUARY 2008 Afternoon

Time: 1 hour

Candidates answer on the question paper.
Additional materials: Electronic calculator
Ruler
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.
- Do **not** write outside the box bordering each page.
- 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	9	
2	16	
3	8	
4	6	
5	12	
6	9	
TOTAL	60	

This document consists of **16** printed pages.

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,	$p = \frac{1}{3}\frac{Nm}{V}<c^2>$
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 Fig. 1.1 shows part of an arrangement used to determine the acceleration of a metal plate that falls vertically.

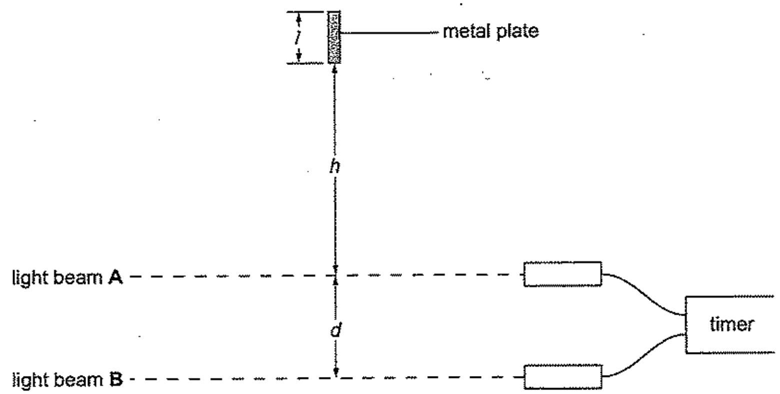


Fig. 1.1

The metal plate is released and falls a distance h of 0.500 m before breaking light beam **A**. The plate falls a further distance d before breaking a second light beam **B**.

(a) Assume the metal plate starts from rest and has an acceleration of 9.81 m s^{-2}.

(i) Show that the time taken for the plate to fall 0.500 m from rest is 0.319 s.

$u = 0,\ s = 0.5,\ a = 9.81,\ t = ?$

$s = ut + \frac{1}{2}at^2$

$t = \sqrt{\frac{2s}{a}} = \sqrt{\frac{2 \times 0.5}{9.81}} = 0.319\,s$ [2]

(ii) Calculate the average speed of the plate over the distance h.

average speed $= \frac{s}{t} = \frac{0.5}{0.319} =$

average speed = 1.57 m s^{-1} [2]

(b) The length l of the plate is measured. This value is entered into the timer. When the plate breaks the light beams **A** and **B**, the timer records the average speed of the plate through each beam. The average speeds through light beams **A** and **B** are 3.05 m s^{-1} and 3.75 m s^{-1} respectively. The distance d = 0.250 m.

(i) Calculate the acceleration of the plate as it falls distance d.

$u = 3.05$, $v = 3.75$, $s = 0.25$, $a = ?$

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

$a = \frac{v^2 - u^2}{2s} = \frac{3.75^2 - 3.05^2}{0.5} = 9.52$

acceleration = 9.52 m s^{-2} [2]

(ii) State and explain **two** reasons why the experimental value obtained for the acceleration of the plate in **(b)(i)** is not the same as the acceleration of free fall used in **(a)**.

Air resistance reduces acceleration.
Sheet could fall at an angle, making average speeds incorrect.

[3]

[Total: 9]

[Turn over

2 Fig. 2.1 shows the variation with time t of the velocity v of a lift travelling from ground level up to the viewing platform of a sky tower.

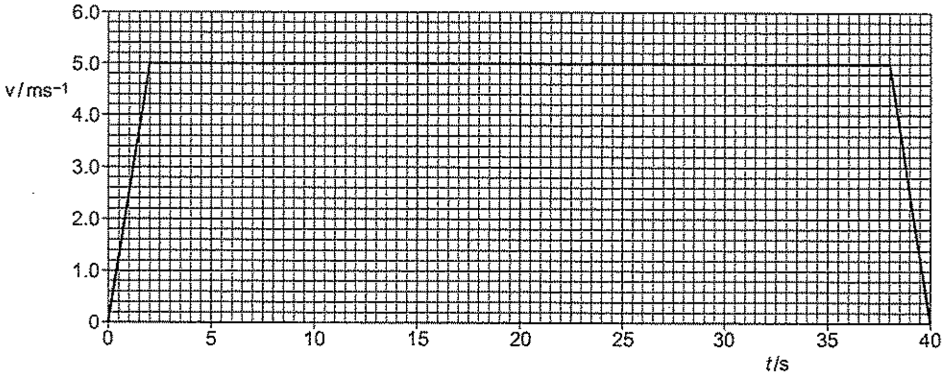


Fig. 2.1

(a) Use Fig. 2.1

(i) to calculate the initial acceleration of the lift

$a = \frac{v - u}{t} = \frac{5 - 0}{2} = 2.5$

acceleration = 2.5 m s^{-2} [2]

(ii) to show that the distance travelled by the lift is 190 m

Area under graph:

$\frac{5 \times 2}{2} + \frac{5 \times 2}{2} + 36 \times 5 = 190 m$

[2]

(iii) to calculate the maximum kinetic energy of a passenger of mass 75 kg

Max v = 5 m s^{-1}

$E_k = \frac{1}{2} m v^2 = \frac{1}{2} \times 75 \times 5^2 = 938 J$

kinetic energy = 938 J [2]

(iv) to calculate the gain in potential energy of the passenger

$E_p = mgh = 75 \times 9.81 \times 190 = 140\,kJ$

potential energy = 140 k J [2]

(v) to calculate the average rate at which potential energy is gained by the passenger for this journey.

$t = 40s$

$P = \frac{E_p}{t} = \frac{140 \times 10^3}{40} = 3.49\,kW$

rate of gain of potential energy = 3.49 unit kW [3]

(b) The passenger exerts a pressure of 55 kPa on the floor of the lift when it is travelling at constant velocity.

(i) Calculate the area of contact between the passenger and the floor.

$W = mg = 75 \times 9.81 = 736\,N$

$P = \frac{F}{A} \Rightarrow A = \frac{F}{P} = \frac{736}{55000} = 0.0134$

area = 0.0134 m^2 [2]

(ii) Without further calculation, state and explain how the values of the pressure exerted on the floor by the passenger during the two periods of acceleration of the lift differ from the value for constant velocity.

During the first period of acceleration, pressure will increase because the upward force needs to be higher than the weight. During deceleration the force up is smaller than the weight, so pressure will be smaller [3]

[Total: 16]

[Turn over

3 **(a)** State the principle of moments.

In equilibrium, ~~clockwise~~ sum of clockwise moments must equal sum of anticlockwise moments. [1]

(b) Fig. 3.1 shows an arrangement used to demonstrate the principle of moments.

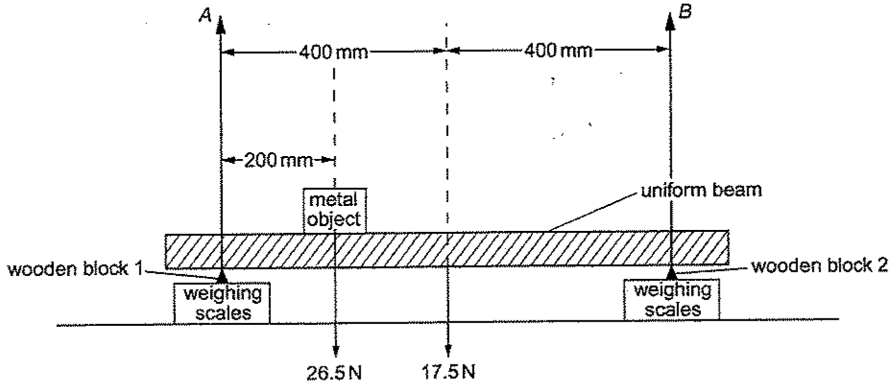


Fig. 3.1

A uniform beam is supported on the edges of two triangular shaped wooden blocks placed on two weighing scales. The weight of the beam is 17.5 N and the distance between the wooden blocks is 800 mm. A metal object of weight 26.5 N is placed 200 mm from one of the blocks. The blocks exert upward forces *A* and *B* on the beam.

(i) Calculate the force *B* by taking moments about wooden block 1.

↻ = ↺

↻ : $17.5 \times 0.4 + 26.5 \times 0.2$

↺ : $0.8B$

$17.5 \times 0.4 + 26.5 \times 0.2 = 0.8B$

$B = 15.4\,N$

force *B* = 15.4 N [3]

(ii) State the sum of the two forces *A* and *B* and explain your answer.

sum = 44 N

In equilibrium, sum of upward forces must equal sum of downward forces. [2]

(iii) Describe what happens to the forces *A* and *B* as the metal object is moved gradually to the centre of the beam.

Force A will decrease and force B will increase by the same amount.

[2]

[Total: 8]

4 Fig. 4.1 shows a girl supported by two elastic ropes. She is in equilibrium. Her weight is 392 N.

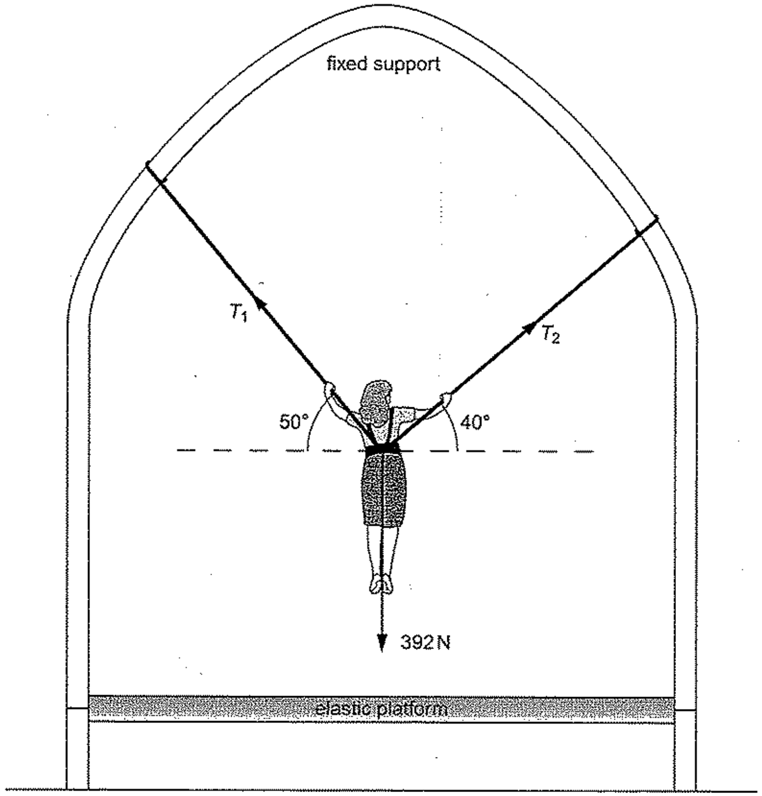


Fig. 4.1

(a) Determine the tensions T_1 and T_2 in the two ropes.

$\leftarrow = \rightarrow \quad T_1 \cos 50° = T_2 \cos 40° \quad — ①$

$\uparrow = \downarrow \quad T_1 \sin 50° + T_2 \sin 40° = 392 \quad — ②$

① $T_1 = T_2 \dfrac{\cos 40°}{\cos 50°} = 1.19 T_2$

② $1.19 T_2 \times \sin 50° + T_2 \sin 40° = 392$

$T_2(1.19 \sin 50° + \sin 40°) = 392$

$T_2 = \dfrac{392}{1.56} = 252 \text{ N}$

$T_1 = 1.19 \times 252 = 300$

tension T_1 = 300 N

tension T_2 = 252 N [4]

(b) The girl is pulled vertically downwards so that the ropes stretch. She is then released. Discuss without further calculation whether the method you used in **(a)** could be used to determine the tensions in the ropes immediately after she is released.

At moment of release, girl is accelerating so not in equilibrium. The tension forces (upward) will be greater than the weight. [2]

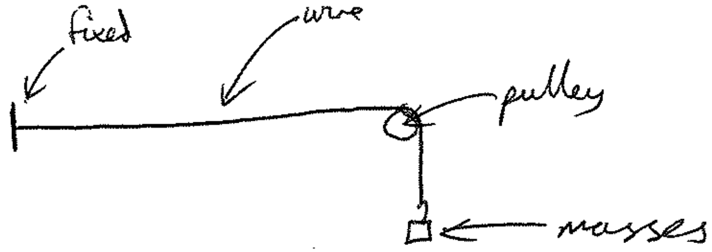
[Total: 6]

[Turn over

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

This question is about an experiment to determine the Young modulus of a metal in the form of a wire.

(a) Describe, with the aid of a diagram, the **apparatus** you would use.



Use a micrometer to measure diameter of wire.
Ruler to measure length and extension.

[2]

(b) Describe how you would make the necessary **measurements**.

Measure length and extension with ruler
Measure diameter with micrometer
Balance to confirm mass of masses.
Check diameter in multiple places

....[4]

(c) Describe how you would determine the Young modulus from your measurements.

$\text{stress} = \frac{\text{Force}}{\text{area}}$

$\text{strain} = \frac{\text{extension}}{\text{length}}$

Plot graph of $\frac{\text{stress}}{\text{strain}} = \frac{Fl}{eA}$ ← $A = \frac{\pi d^2}{4}$

Find gradient of stress-strain graph.

....[4]

Quality of Written Communication [2]

[Total: 12]

6 (a) With reference to the driving of a car define the terms

(i) *thinking distance* Distance travelled from driver seeing incident until brakes are applied.

(ii) *braking distance.* Distance travelled from brakes being applied until car has stopped. [2]

(b) Fig. 6.1 shows a car travelling along a road that has a uniform downhill gradient.

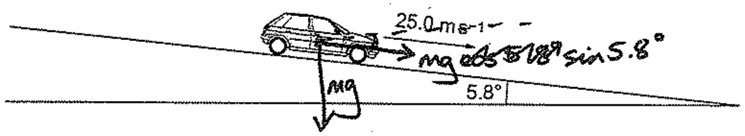


Fig. 6.1

The car has a total mass of 850 kg and is travelling at a constant speed of 25.0 m s^{-1}. The driver sees a hazard ahead and applies the brakes to stop the car. The reaction time of the driver is 0.62 s. When the brakes are applied the braking force is a constant 5520 N.

(i) Calculate the thinking distance.

$s = vt = 25 \times 0.62 =$

thinking distance = 15.5 m [2]

(ii) The angle of the road to the horizontal is 5.8°. Show that the deceleration with the brakes applied is 5.50 m s^{-2}.

Component of weight down slope $= mg \sin 5.8°$
$= 850 \times 9.81 \sin 5.8°$
$= 843\text{N}$

Net braking force $= 5520 - 843$
$= 4677\text{N}$

$F = ma$

$a = \frac{F}{m} = \frac{4677}{850} = 5.50$

deceleration = 5.50 m s^{-2} [3]

(iii) Calculate the braking distance of the car.

$u = 25$, $v = 0$, $a = -5.5$, $s = ?$

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

$s = \frac{v^2 - u^2}{2a} = \frac{0 - 25^2}{2 \times -5.5} =$

braking distance = 56.8 m [2]

[Total: 9]

END OF QUESTION PAPER

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