Mr Cowen's answers

THIS IS A LEGACY SPECIFICATION

OCR
RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE

PHYSICS A 2821

Forces and Motion

Tuesday 13 January 2009
Afternoon

Duration: 1 hour

Candidates answer on the question paper

OCR Supplied Materials:
None

Other Materials Required:
- Electronic calculator
- Ruler
- Protractor

Candidate Forename	Cowen	Candidate Surname	Physics
Centre Number		Candidate Number	

INSTRUCTIONS TO CANDIDATES

- Write your name clearly in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use 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, however additional paper may be used if necessary.

INFORMATION FOR CANDIDATES

- The number of marks 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.
- This document consists of **16** pages. Any blank pages are indicated.

FOR EXAMINER'S USE		
Qu.	Max.	Mark
1	16	
2	8	
3	10	
4	6	
5	10	
6	10	
TOTAL	60	

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, $p = \frac{1}{3}\dfrac{Nm}{V}\langle c^2\rangle$

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

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

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

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 A projectile is fired, from ground level, into the air at a velocity of 50 m s^{-1} and 53° to the horizontal. Fig. 1.1 shows the variation of the vertical component of the velocity v_v against time, t, until the projectile reaches its maximum height at 4.1 s.

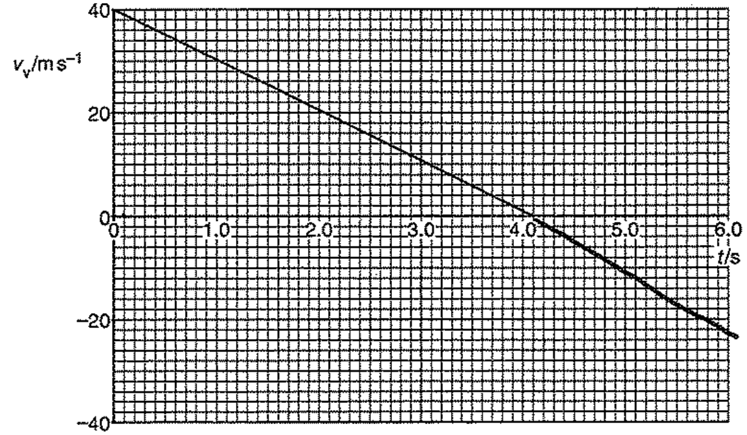


Fig. 1.1

Fig. 1.2 shows the variation of the horizontal component of the velocity v_h against time, t, for the same part of the journey.

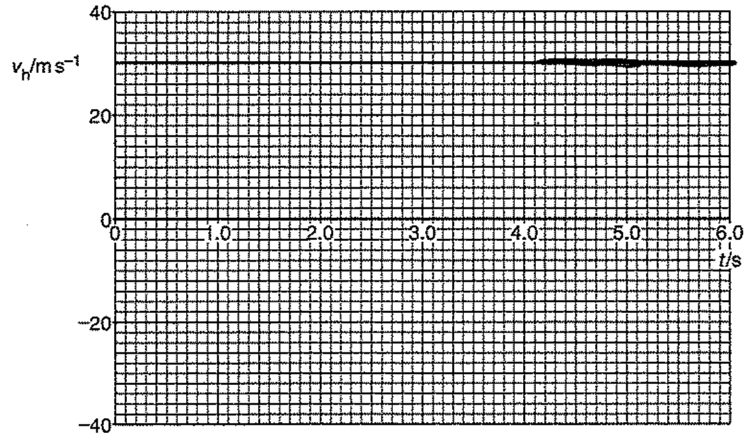


Fig. 1.2

(a) **(i)** Use Figs. 1.1 and 1.2 to describe the motion of the projectile

1 in the vertical direction

The projectile decelerates at a constant rate **[1]**

2 in the horizontal direction.

Constant velocity **[1]**

(ii) Use Figs. 1.1 and 1.2 to calculate at the maximum height

1 the vertical displacement

Area under graph: $\frac{40\times4.1}{2} = 82$

vertical displacement = 82 m **[2]**

2 the horizontal displacement.

Area under graph: $30\times4.1 = \cancel{61.5}\ 123$

horizontal displacement = ~~61.5~~ 123 m **[1]**

(b) Describe the difference between the distance travelled by the projectile and the displacement of the projectile.

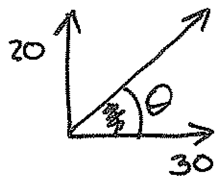
The projectile's ~~has a~~ distance is the arc that it has travelled along, the displacement is the shorter ~~distance~~ length in a straight line from start to end. **[2]**

(c) **(i)** Use Figs. 1.1 and 1.2 to determine v_v and v_h after 2.0 s.

v_v = 20 ms^{-1}

v_h = 30 ms^{-1} **[1]**

(ii) Hence or otherwise calculate the velocity of the projectile after 2.0 s.



$20^2 + 30^2 = 36.1$

$\tan\theta = \frac{20}{30}$

$\theta = \tan^{-1}\left(\frac{20}{30}\right) = 33.7^\circ$

magnitude of the velocity = 36.1 ms^{-1}

angle of velocity to the horizontal = 33.7 ° **[4]**

(iii) State the magnitude of the velocity of the projectile after 4.1 s.

velocity = 30 ms^{-1} **[1]**

(d) Continue the graphs in Figs. 1.1 and 1.2 to show how the velocity of the projectile varies up to 6.0 s. **[3]**

[Total: 16]

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2 Fig. 2.1 shows apparatus used to determine the acceleration due to gravity.

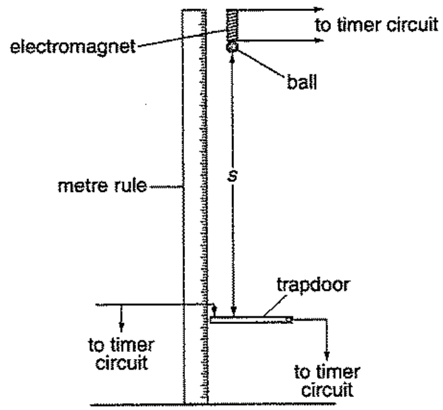

Fig. 2.1

A clock starts when a ball is released from an electromagnet and stops when the ball opens a trapdoor. The clock then displays the time t for the ball to fall a distance s. The trapdoor is moved to change the value of s. Fig. 2.2 shows the variation of t^2 against distance s.

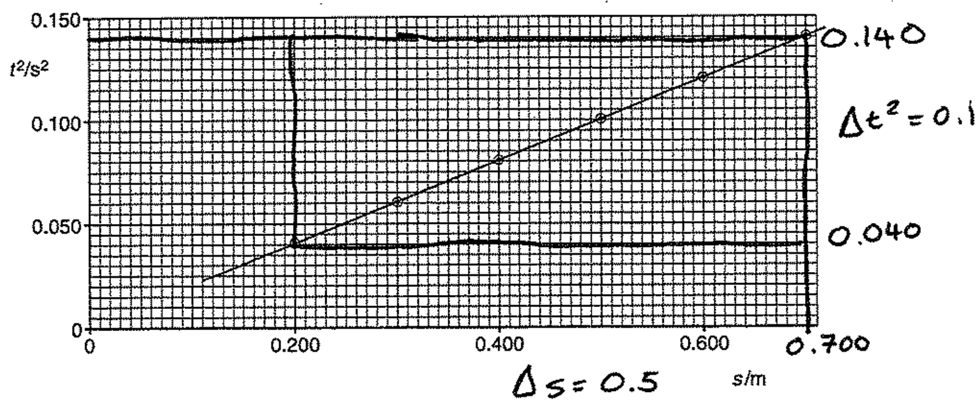

Fig. 2.2

(a) Use an equation of motion to explain why the graph in Fig. 2.2 is a straight line.

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

$t^2 = \frac{2s}{a}$ Gradient $= \frac{2}{a}$ **[2]**

(b) Use Fig. 2.2 to calculate

(i) the gradient of the graph

$m = \frac{0.1}{0.5} = 0.20$

gradient = 0.20 **[2]**

(ii) the acceleration of the ball.

$0.2 = \frac{2}{a}$ $a = \frac{2}{0.2} = 10.0$

acceleration = 10.0 ms^{-2} **[2]**

(c) When a student performs this experiment he obtains a straight line graph which does not pass through the origin. Suggest **two** reasons why.

Air resistance.

Time delay releasing ball.

[2]

[Total: 8]

3 (a) Define

(i) the *newton*

The force required to accelerate 1kg by $1ms^{-2}$. **[1]**

(ii) *work done by a force.*

Work done by a force is equal to the force multiplied by the distance moved in the direction of the force. **[1]**

(b) A car of mass *m* is travelling at a speed *u*. A constant braking force *F* is applied until the car comes to rest. The car travels a distance *s* after the force is applied.

(i) Write equations for

1 the work done by the force *F*

$W = Fs$

2 the relationship between the force *F* and acceleration *a*.

$F = ma$

[1]

(ii) Use the equations in **(i)** to show that the work done bringing the car to rest equals the loss in kinetic energy of the car.

$\cancel{E_k = \frac{1}{2}mat}$ $W = mas$

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

$v = 0$

$u^2 = -2as$

$as = -\frac{u^2}{2}$

$W = -m\frac{u^2}{2} = -\frac{1}{2}mu^2 = E_k$

[3]

(iii) Hence describe the relationship between the braking distance and the velocity of a car.

Braking distance is proportional to square of velocity.

[1]

(c) (i) A car of mass 1550 kg has a braking distance of 25.0 m when travelling at 13.3 m s^{-1}. Calculate the average braking force acting on the car.

$s=25,\ u=13.3,\ v=0,\ a=?$

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

$a=\dfrac{v^2-u^2}{2s}=\dfrac{-13.3^2}{2\times 25}=-3.5\,ms^{-2}$

$F=ma=1550\times 3.5$

$=5500$

force = 5500 N [2]

(ii) Deduce the braking distance when the car is travelling at 26.6 m s^{-1} and the same braking force is applied.

$25=k\,13.3^2$

$k=\dfrac{25}{13.3^2}=0.141$

$26.6^2\times 0.141=100$

distance = 100 m [1]

[Total: 10]

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

Force per unit area

[1]

(ii) Define *density*.

Mass per unit volume

[1]

(b) Fig. 4.1 shows the outline of a swimming pool that is on the top floor of a building.

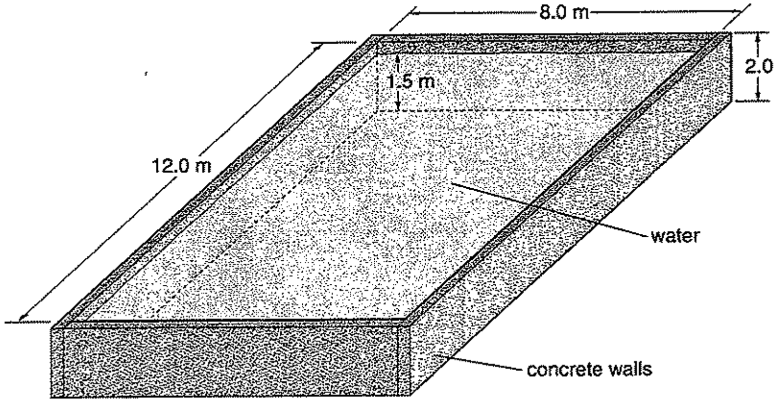

Fig. 4.1

The total volume of concrete used is 27 m^3. The density of the concrete is 2600 kg m^{-3}.

(i) Calculate the mass of concrete.

$2600\times 27=70200$

mass = 70200 kg [1]

(ii) The pool contains water to a constant depth of 1.5 m. The internal dimensions of the pool are 8.0 m by 12.0 m. The density of water is 1000 kg m^{-3}.
Calculate the pressure the water exerts on the base of the pool.

$V = 1.5 \times 8 \times 12 = 144\,m^3$

$m = 144 \times 1000 = 144000$ kg

$p = \frac{F}{A} = \frac{mg}{A} = \frac{144000 \times 9.81}{8 \times 12} = 14.7$ kPa

pressure = 14.7 kPa [2]

(iii) Suggest with a reason whether the pressure on the floor under the concrete walls or under the water is greater.

The concrete because it is more dense and has higher walls.

.... [1]

[Total: 6]

5 (a) Define the *centre of gravity* of a body.

The point about which the weight of an object can be assumed to act. [1]

Fig. 5.1 shows a boat being lifted vertically. It is attached to two ropes labelled **1** and **2**. A motor lifts the boat vertically.

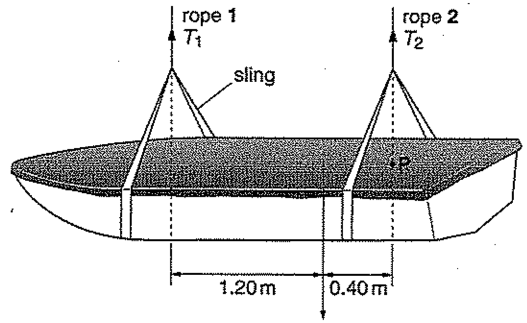

Fig. 5.1

(b) When the boat is rising at a constant speed the tensions in ropes **1** and **2** are T_1 and T_2 respectively. The weight of the boat is 22 kN. The weight acts 1.20 m and 0.40 m from the lines of action of the tensions T_1 and T_2 respectively.

(i) Explain why the rising boat can be described as being in equilibrium.

Travelling at constant ~~speed~~ velocity.

.... [1]

(ii) Calculate the moment of the weight of the boat about the point **P**.

~~$1.6T_1 =$~~

moment $= 0.4 \times 22000 = 8800$ Nm

moment = 8800 unit Nm [2]

(iii) Calculate the tension T_1.

$1.6T_1 = \cancel{22000}\ 8800$

$T_1 = \frac{8800}{1.6} = 5500$ N

T_1 = 5500 N [2]

(iv) Calculate the tension T_2.

$5500 + T_2 = 22000$

$T_2 = 22000 - 5500 = 16500$

$T_2 =$ 16500 N [1]

(v) Calculate the minimum power required by the motor to lift the boat at a constant speed of $0.015\,ms^{-1}$.

$P = Fv = 22000 \times 0.015$

$= 330W$

power = 330 W [2]

(c) Describe and explain one situation during the lifting of the boat when it will not be in equilibrium.

When it is accelerating at start ~~to end~~.

[1]

[Total: 10]

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

(a) Use the following terms to explain the behaviour of a spring when a tensile force is applied:

extension **Hooke's law** **elastic limit** **spring constant**

Extension is the increase in the spring length when a force is applied.

Hooke's law: force is proportional to extension, as long as elastic limit is not exceeded.

Elastic limit is the maximum force before the spring suffers permanent deformation.

[3]

Force constant $= k = \frac{\text{force}}{\text{extension}}$

THIS QUESTION CONTINUES ON PAGE 16

[Turn over

(b) Describe how the following terms may be used to compare materials:

stiff **strong** **brittle** **ductile**

In your answer you should include the quantities stress, strain and Young modulus and the terms elastic and plastic.

Stiff material has a high Young mod.

Strong materal can take a high stress before breaking

Brittle materials have no plastic deformation.

Ductile materials have large plastic region.

Young mod $= \frac{\text{stress}}{\text{strain}}$

[5]

Quality of Written Communication [2]

[Total: 10]

END OF QUESTION PAPER