OCR
RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE UNIT **2821**

PHYSICS A

Forces and Motion

FRIDAY 12 JANUARY 2007 Afternoon

Time: 1 hour

Additional materials: Electronic Calculator
Ruler (cm/mm)
Protractor

Candidate Name

Centre Number

Candidate Number

INSTRUCTIONS TO CANDIDATES

- Write your name, Centre Number and Candidate Number in the boxes above.
- Answer **all** the questions.
- Use blue or black ink. 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 outside the box bordering each page.
- WRITE YOUR ANSWER TO EACH QUESTION IN THE SPACE PROVIDED. ANSWERS WRITTEN ELSEWHERE WILL NOT BE MARKED.

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	8	
2	9	
3	10	
4	12	
5	10	
6	11	
TOTAL	60	

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

[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 Fig. 1.1 shows the path of a ball thrown from **A** and passing through positions **B**, **C** and **D**.

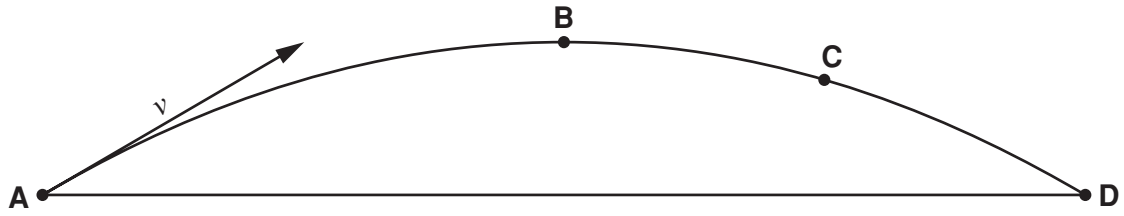

Fig. 1.1

The ball is thrown from **A** with a velocity v. A vector arrow on Fig. 1.1 represents the magnitude and direction of the velocity of the ball at **A**.

(a) On Fig. 1.1 draw arrows to represent the horizontal and vertical components of the velocity of the ball at **A**. [1]

(b) State how the components of the velocity of the ball at **B**, **C** and **D** compare with the components at **A**. Assume air resistance is negligible.

(i) The vertical component at **B** .....

The horizontal component at **B** .....[1]

(ii) The vertical component at **C** .....

The horizontal component at **C** .....[1]

(iii) The vertical component at **D** .....

The horizontal component at **D** .....[1]

(c) Explain the answers you have given for the components of the velocity of the ball at positions **B**, **C** and **D**.

.....

.....

.....

.....

.....

.....[4]

[Total: 8]

2 **(a)** Explain, with reference to a car, the quantities

(i) *braking force*

.....

.....

.....[1]

(ii) *braking distance.*

.....

.....

.....[1]

(b) A car of mass 1380 kg, travelling at 31.1 m s^{-1}, is brought to rest by the brakes in 48.2 m.

Calculate

(i) the initial kinetic energy of the car

kinetic energy = ... J [3]

(ii) the average deceleration of the car

deceleration = ... m s^{-2} [2]

(iii) the average braking force.

braking force = ... N [2]

[Total: 9]

3 **(a)** Define the quantities

(i) *work*

.....

.....[1]

(ii) *power.*

.....

.....[1]

(b) Define the *watt*.

.....

.....[1]

(c) Fig. 3.1 shows a crane that is used to move heavy objects.

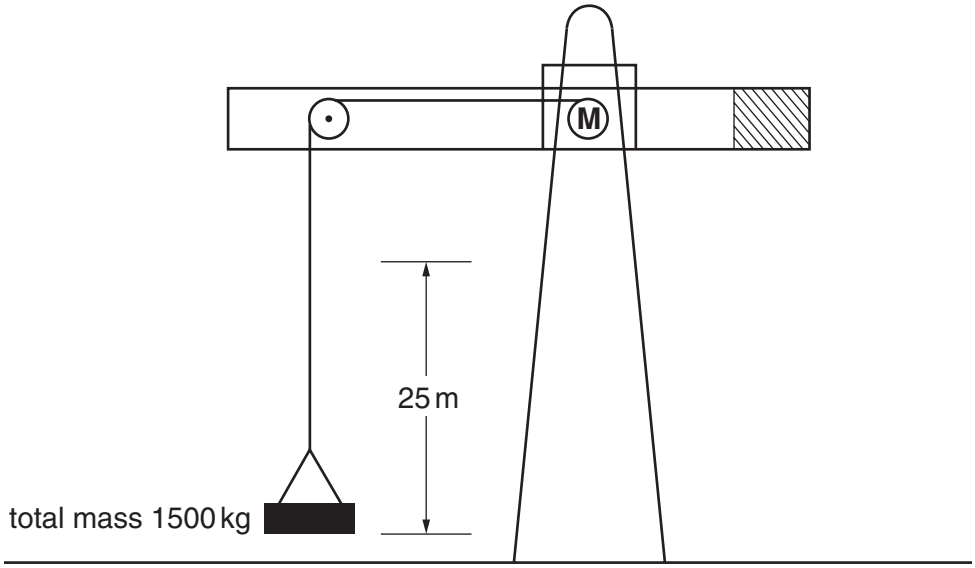

Fig. 3.1

The motor **M** in the crane lifts a total mass of 1500 kg through a height of 25 m at a constant velocity of 1.6 m s^{-1}.

Calculate

(i) the tension in the lifting cable

tension = ... N [2]

(ii) the time taken for the mass to be raised through the height of 25 m

time = ... s [1]

(iii) the rate of gain of potential energy of the mass

rate of gain of potential energy = ... $J s^{-1}$ [3]

(iv) the minimum output power of the motor used to raise the mass.

power = ... W [1]

[Total: 10]

4 **(a)** Define

(i) the *moment* of a force

.....

.....[2]

(ii) the *torque* of a couple.

.....

.....[1]

(b) Fig. 4.1 shows a uniform rectangular beam supported by two straps. The beam is in equilibrium.

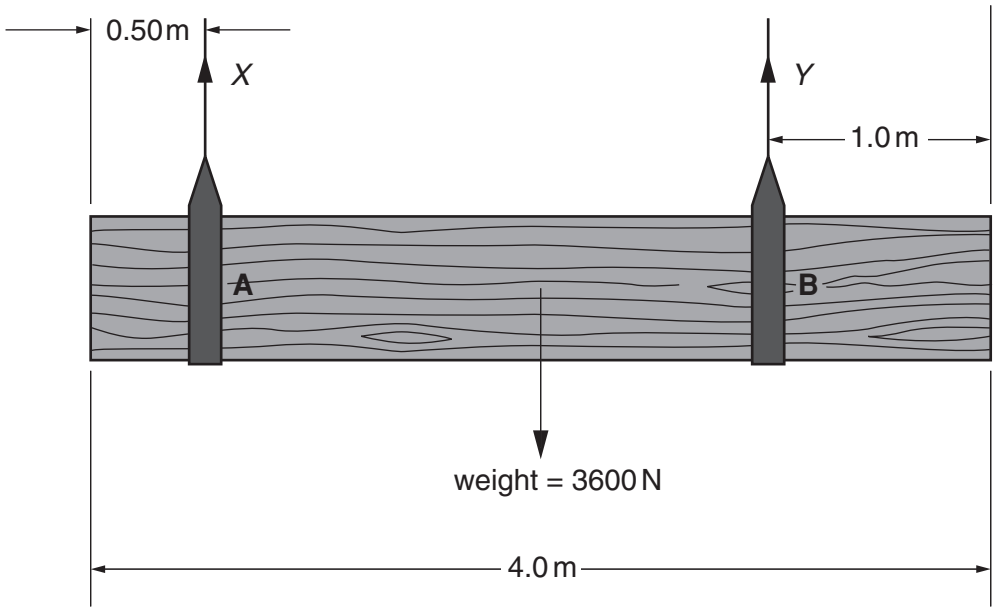

Fig. 4.1

The weight of the beam is 3600 N and its length is 4.0 m. The strap **A** is positioned 0.50 m from one end of the beam and the strap **B** is positioned 1.0 m from the other end.

(i) **1** Use the principle of moments to show that the upward force *X* at strap **A** is 1440 N.

[2]

2 Hence determine the force *Y* at the strap **B**.

force = ... N [2]

(ii) Discuss whether the forces *X* and *Y* provide a couple.

.....

.....

.....

.....[2]

(iii) The area of strap **A** in contact with the underside of the beam is $2.3 \times 10^{-2}\,m^2$. Calculate the average pressure exerted on the beam by strap **A**.

pressure = ... unit ..... [3]

[Total: 12]

5 **(a)** Define the quantities

(i) *stress*

.....[1]

(ii) *strain.*

.....[1]

(b) The results given in Table 5.1 are obtained in an experiment to determine the Young modulus of a metal in the form of a wire. The wire is loaded in steps of 5.0 N up to 25.0 N and then unloaded.

	loading	unloading
load / N	extension / mm	extension / mm
0.0	0.00	0.00
5.0	0.24	0.24
10.0	0.47	0.48
15.0	0.71	0.71
20.0	0.96	0.95
25.0	1.20	1.20

Table 5.1

(i) Using the results in Table 5.1 and without plotting a graph, state and explain whether the deformation of the wire

1 is plastic or elastic

.....

.....

.....[1]

2 obeys Hooke's law.

.....

.....

.....[2]

(ii) Explain how the extension and length of the wire may be determined experimentally.

.....

.....

.....

.....[2]

(iii) The wire tested is 1.72 m long and has a cross-sectional area of $1.80 \times 10^{-7}\,m^2$. Use the extension value given in Table 5.1 for a load of 25.0 N to calculate the Young modulus of the metal of the wire.

Young modulus = ... Pa [3]

[Total: 10]

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

Fig. 6.1 shows a graph of the displacement against time for the motion of a radio-controlled model car.

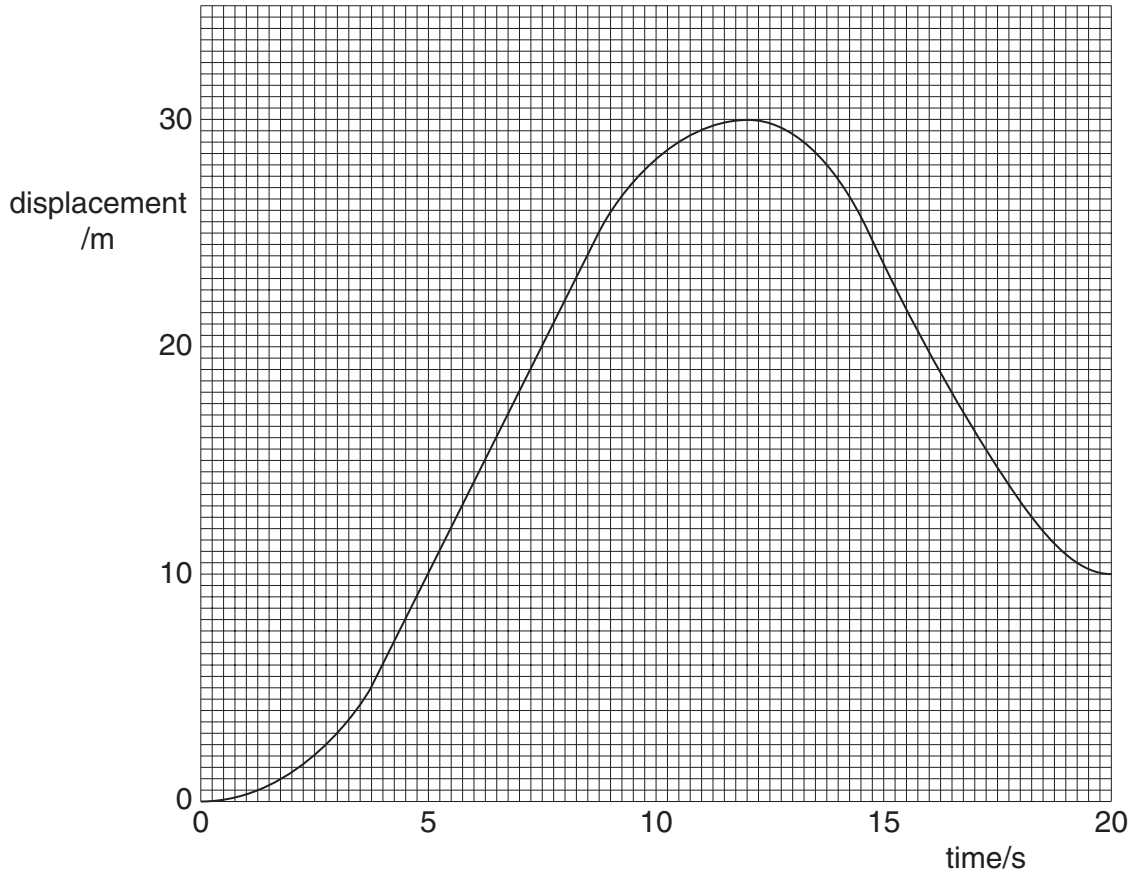

Fig. 6.1

Use Fig. 6.1 to describe and explain, without calculation

(a) how the velocity changes from time $t = 0$ to time $t = 20\,s$

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.....[5]

(b) how the acceleration changes from time $t = 0$ to time $t = 20$ s.

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.....[4]

Quality of Written Communication [2]

[Total: 11]

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