

**ADVANCED SUBSIDIARY GCE UNIT  
PHYSICS A**

Forces and Motion

**FRIDAY 12 JANUARY 2007**

**2821**

Afternoon

Time: 1 hour

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



Candidate  
Name

Centre  
Number

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Candidate  
Number

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**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	
<b>TOTAL</b>	<b>60</b>	

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



**Data**

speed of light in free space,	$c = 3.00 \times 10^8 \text{ m s}^{-1}$
permeability of free space,	$\mu_0 = 4\pi \times 10^{-7} \text{ H m}^{-1}$
permittivity of free space,	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$
elementary charge,	$e = 1.60 \times 10^{-19} \text{ C}$
the Planck constant,	$h = 6.63 \times 10^{-34} \text{ J s}$
unified atomic mass constant,	$u = 1.66 \times 10^{-27} \text{ kg}$
rest mass of electron,	$m_e = 9.11 \times 10^{-31} \text{ kg}$
rest mass of proton,	$m_p = 1.67 \times 10^{-27} \text{ kg}$
molar gas constant,	$R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$
the Avogadro constant,	$N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$
gravitational constant,	$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
acceleration of free fall,	$g = 9.81 \text{ m s}^{-2}$



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

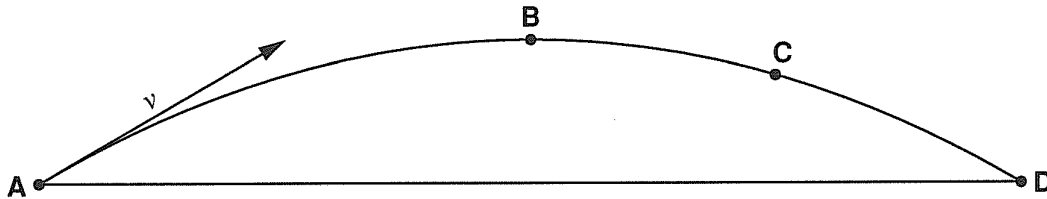


Fig. 1.1

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  $31.1 \text{ ms}^{-1}$ , is brought to rest by the brakes in 48.2m.

Calculate

(i) the initial kinetic energy of the car

kinetic energy = ..... J [3]

(ii) the average deceleration of the car

deceleration = .....  $\text{ms}^{-2}$  [2]

(iii) the average braking force.

braking force = ..... N [2]

[Total: 9]

[Turn over



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.

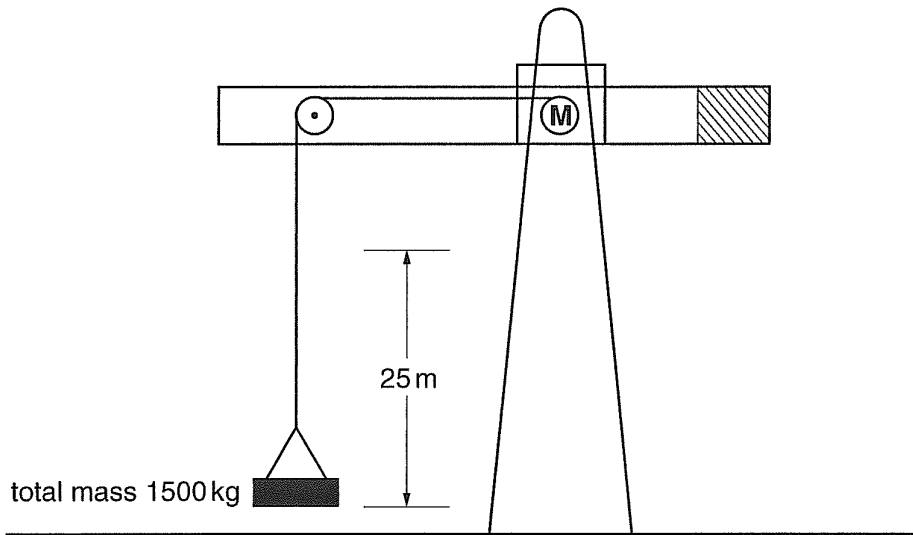


Fig. 3.1

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

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 = .....  $\text{Js}^{-1}$  [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.

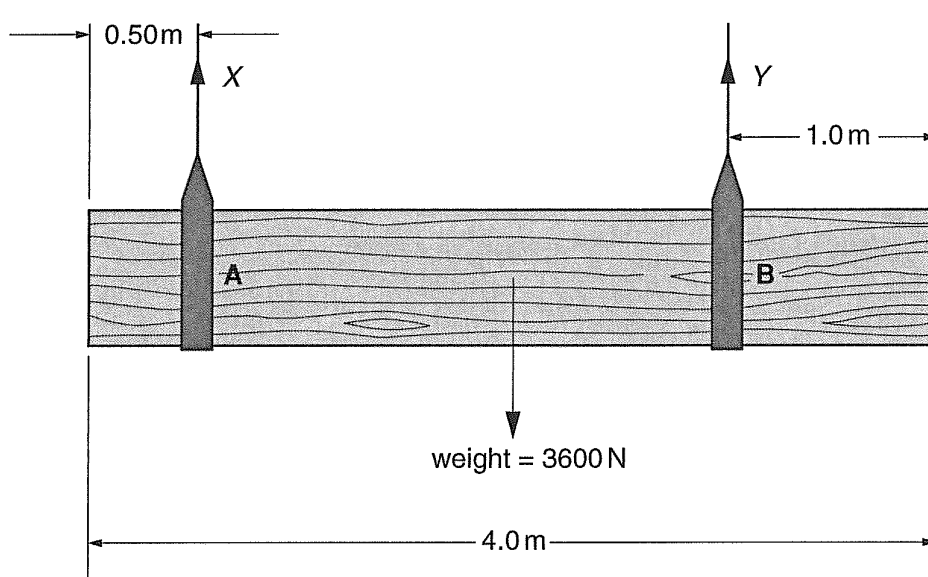


Fig. 4.1

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  $2.3 \times 10^{-2} \text{ m}^2$ . 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 5.0N up to 25.0N 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  $1.80 \times 10^{-7} \text{ m}^2$ . 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.

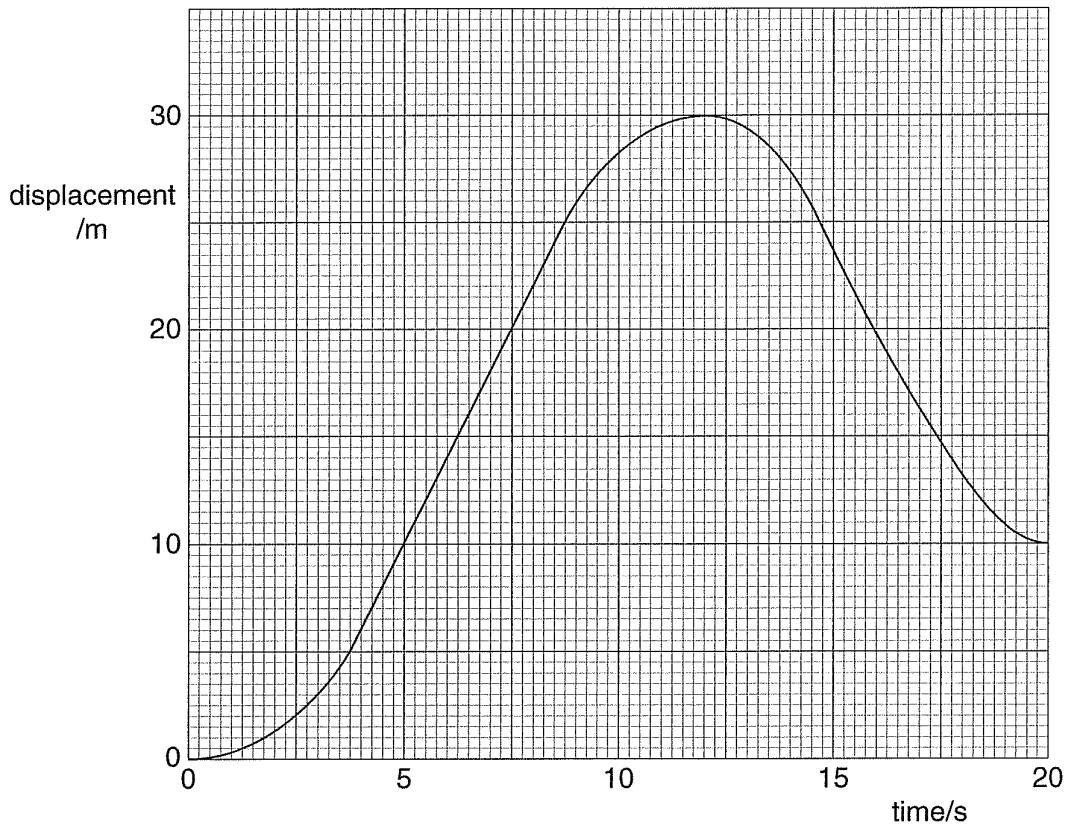


Fig. 6.1

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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