

Paper Reference(s)

**6678**

**Edexcel GCE**

**Mechanics M2**

**Advanced Subsidiary**

**Wednesday 12 January 2005 – Afternoon**

**Time: 1 hour 30 minutes**

**Materials required for examination**

Mathematical Formulae (Lilac or Green)

**Items included with question papers**

Nil

Candidates may use any calculator EXCEPT those with the facility for symbolic algebra, differentiation and/or integration. Thus candidates may NOT use calculators such as the Texas Instruments TI 89, TI 92, Casio CFX 9970G, Hewlett Packard HP 48G.

**Instructions to Candidates**

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In the boxes on the answer book, write the name of the examining body (Edexcel), your centre number, candidate number, the unit title (Mechanics M2), the paper reference (6678), your surname, other name and signature.

Whenever a numerical value of  $g$  is required, take  $g = 9.8 \text{ m s}^{-2}$ .

When a calculator is used, the answer should be given to an appropriate degree of accuracy.

**Information for Candidates**

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A booklet 'Mathematical Formulae and Statistical Tables' is provided.

Full marks may be obtained for answers to ALL questions.

This paper has seven questions.

The total mark for this paper is 75.

**Advice to Candidates**

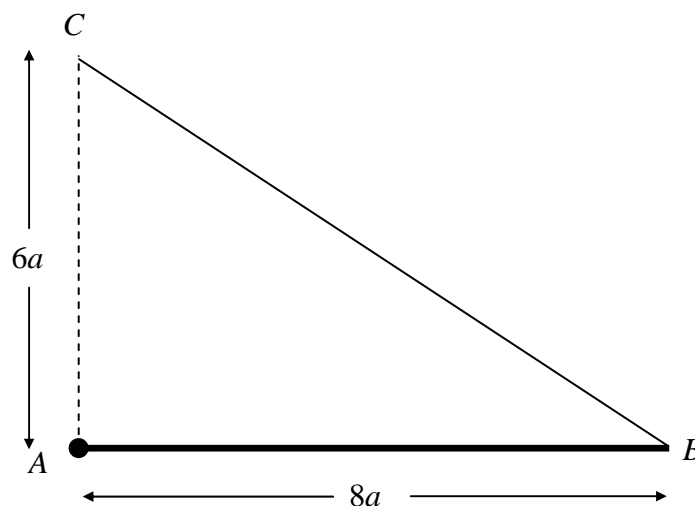
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You must ensure that your answers to parts of questions are clearly labelled.

You must show sufficient working to make your methods clear to the Examiner. Answers without working may gain no credit.

1.

Figure 1



A uniform rod  $AB$ , of length  $8a$  and weight  $W$ , is free to rotate in a vertical plane about a smooth pivot at  $A$ . One end of a light inextensible string is attached to  $B$ . The other end is attached to point  $C$  which is vertically above  $A$ , with  $AC = 6a$ . The rod is in equilibrium with  $AB$  horizontal, as shown in Figure 1.

- (a) By taking moments about  $A$ , or otherwise, show that the tension in the string is  $\frac{5}{6}W$ . (4)
- (b) Calculate the magnitude of the horizontal component of the force exerted by the pivot on the rod. (3)
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2.

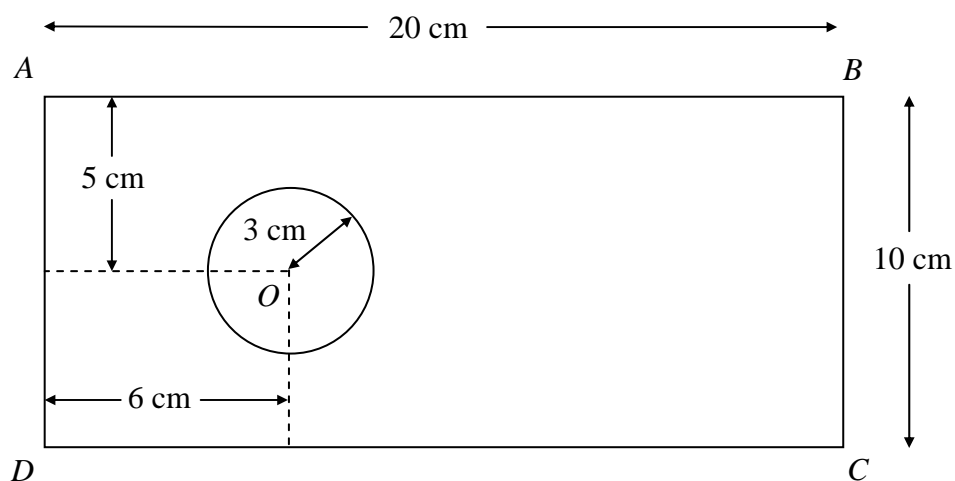
**Figure 2**

Figure 2 shows a metal plate that is made by removing a circle of centre  $O$  and radius 3 cm from a uniform rectangular lamina  $ABCD$ , where  $AB = 20$  cm and  $BC = 10$  cm. The point  $O$  is 5 cm from both  $AB$  and  $CD$  and is 6 cm from  $AD$ .

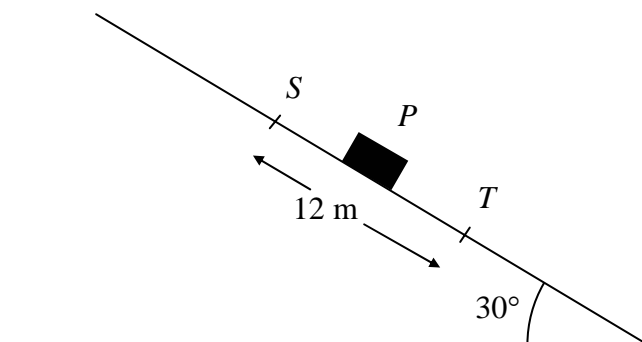
- (a) Calculate, to 3 significant figures, the distance of the centre of mass of the plate from  $AD$ . (5)

The plate is freely suspended from  $A$  and hangs in equilibrium.

- (b) Calculate, to the nearest degree, the angle between  $AB$  and the vertical. (3)
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3.

Figure 3



A small package  $P$  is modelled as a particle of mass  $0.6 \text{ kg}$ . The package slides down a rough plane from a point  $S$  to a point  $T$ , where  $ST = 12 \text{ m}$ . The plane is inclined at an angle of  $30^\circ$  to the horizontal and  $ST$  is a line of greatest slope of the plane, as shown in Figure 3. The speed of  $P$  at  $S$  is  $10 \text{ m s}^{-1}$  and the speed of  $P$  at  $T$  is  $9 \text{ m s}^{-1}$ . Calculate

(a) the total loss of energy of  $P$  in moving from  $S$  to  $T$ , (4)

(b) the coefficient of friction between  $P$  and the plane. (5)

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4. A particle  $P$  of mass  $0.4 \text{ kg}$  is moving under the action of a single force  $\mathbf{F}$  newtons. At time  $t$  seconds, the velocity of  $P$ ,  $\mathbf{v} \text{ m s}^{-1}$ , is given by

$$\mathbf{v} = (6t + 4)\mathbf{i} + (t^2 + 3t)\mathbf{j}.$$

When  $t = 0$ ,  $P$  is at the point with position vector  $(-3\mathbf{i} + 4\mathbf{j}) \text{ m}$ . When  $t = 4$ ,  $P$  is at the point  $S$ .

(a) Calculate the magnitude of  $\mathbf{F}$  when  $t = 4$ . (4)

(b) Calculate the distance  $OS$ . (5)

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5. A car of mass 1000 kg is towing a trailer of mass 1500 kg along a straight horizontal road. The tow-bar joining the car to the trailer is modelled as a light rod parallel to the road. The total resistance to motion of the car is modelled as having constant magnitude 750 N. The total resistance to motion of the trailer is modelled as of magnitude  $R$  newtons, where  $R$  is a constant. When the engine of the car is working at a rate of 50 kW, the car and the trailer travel at a constant speed of  $25 \text{ m s}^{-1}$ .

(a) Show that  $R = 1250$ .

(3)

When travelling at  $25 \text{ m s}^{-1}$  the driver of the car disengages the engine and applies the brakes. The brakes provide a constant braking force of magnitude 1500 N to the car. The resisting forces of magnitude 750 N and 1250 N are assumed to remain unchanged. Calculate

(b) the deceleration of the car while braking,

(3)

(c) the thrust in the tow-bar while braking,

(2)

(d) the work done, in kJ, by the braking force in bringing the car and the trailer to rest.

(4)

(e) Suggest how the modelling assumption that the resistances to motion are constant could be refined to be more realistic.

(1)

6. A particle  $P$  of mass  $3m$  is moving with speed  $2u$  in a straight line on a smooth horizontal table. The particle  $P$  collides with a particle  $Q$  of mass  $2m$  moving with speed  $u$  in the opposite direction to  $P$ . The coefficient of restitution between  $P$  and  $Q$  is  $e$ .

(a) Show that the speed of  $Q$  after the collision is  $\frac{1}{5}u(9e + 4)$ .

(5)

As a result of the collision, the direction of motion of  $P$  is reversed.

(b) Find the range of possible values of  $e$ .

(5)

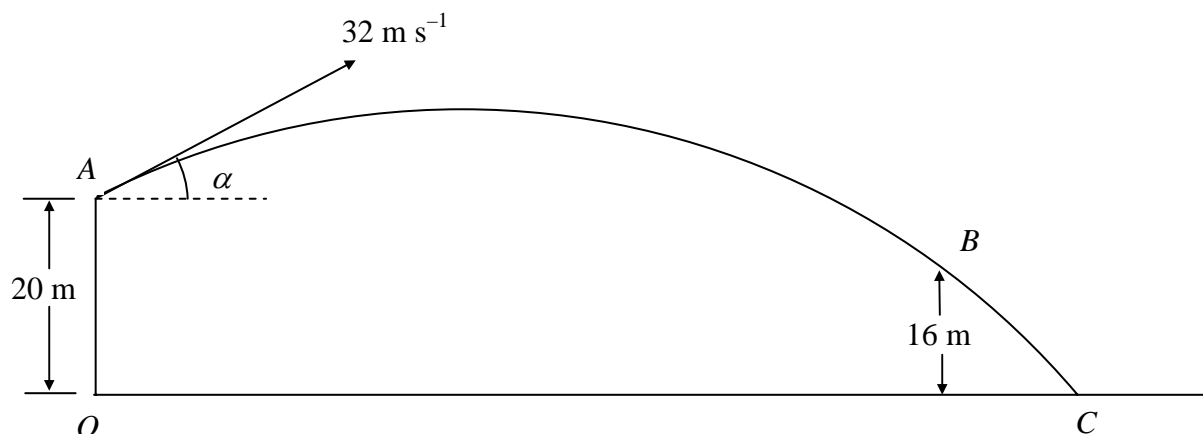
Given that the magnitude of the impulse of  $P$  on  $Q$  is  $\frac{32}{5}mu$ ,

(c) find the value of  $e$ .

(4)

7.

Figure 4



A particle  $P$  is projected from a point  $A$  with speed  $32 \text{ m s}^{-1}$  at an angle of elevation  $\alpha$ , where  $\sin \alpha = \frac{3}{5}$ . The point  $O$  is on horizontal ground, with  $O$  vertically below  $A$  and  $OA = 20 \text{ m}$ . The particle  $P$  moves freely under gravity and passes through a point  $B$ , which is  $16 \text{ m}$  above ground, before reaching the ground at the point  $C$ , as shown in Figure 4.

Calculate

- (a) the time of the flight from  $A$  to  $C$ , (5)
- (b) the distance  $OC$ , (3)
- (c) the speed of  $P$  at  $B$ , (4)
- (d) the angle that the velocity of  $P$  at  $B$  makes with the horizontal. (3)

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**TOTAL FOR PAPER: 75 MARKS**

**END**