

Paper Reference(s)

**6679/01**

# **Edexcel GCE**

## **Mechanics M3**

### **Advanced Subsidiary**

**Wednesday 25 January 2006 – Morning**

**Time: 1 hour 30 minutes**

**Materials required for examination**

Mathematical Formulae (Lilac)

**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 M3), the paper reference (6679), 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.

The marks for individual questions and the parts of questions are shown in round brackets: e.g. (2).

There are 7 questions on this paper. The total mark for this paper is 75.

#### **Advice to Candidates**

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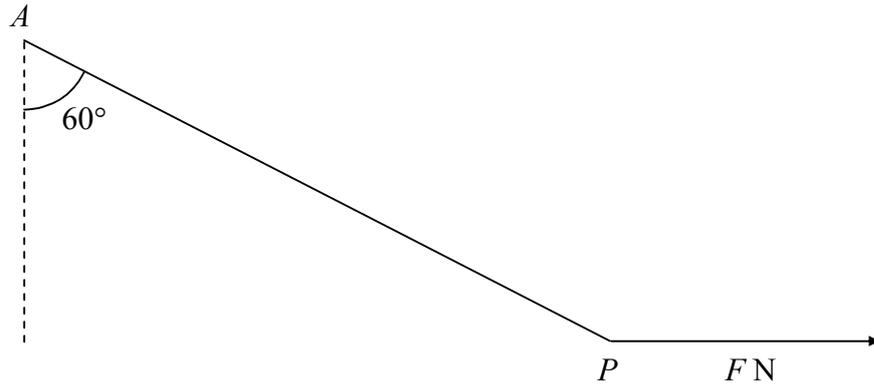
You must ensure that your answers to parts of questions are clearly labelled.

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

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1.

Figure 1



A particle  $P$  of mass  $0.8$  kg is attached to one end of a light inelastic string, of natural length  $1.2$  m and modulus of elasticity  $24$  N. The other end of the string is attached to a fixed point  $A$ . A horizontal force of magnitude  $F$  newtons is applied to  $P$ . The particle  $P$  is in equilibrium with the string making an angle  $60^\circ$  with the downward vertical, as shown in Figure 1.

Calculate

- (a) the value of  $F$ , (3)
- (b) the extension of the string, (3)
- (c) the elasticity stored in the string. (2)
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2. A particle  $P$  moves along the  $x$ -axis. At time  $t$  seconds the velocity of  $P$  is  $v$  m s<sup>-1</sup> and its acceleration is  $2 \sin \frac{1}{2} t$  m s<sup>-2</sup>, both measured in the direction of  $Ox$ . Given that  $v = 4$  when  $t = 0$ ,

- (a) find  $v$  in terms of  $t$ , (4)
- (b) calculate the distance travelled by  $P$  between the times  $t = 0$  and  $t = \frac{\pi}{2}$ . (4)
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3. A rocket is fired vertically upwards with speed  $U$  from a point on the Earth's surface. The rocket is modelled as a particle  $P$  of constant mass  $m$ , and the Earth as a fixed sphere of radius  $R$ . At a distance  $x$  from the centre of the Earth, the speed of  $P$  is  $v$ . The only force acting on  $P$  is directed towards the centre of the Earth and has magnitude  $\frac{cm}{x^2}$ , where  $c$  is a constant.

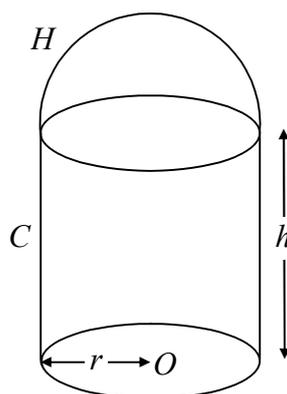
(a) Show that  $v^2 = U^2 + 2c\left(\frac{1}{x} - \frac{1}{R}\right)$ . (5)

The kinetic energy of  $P$  at  $x = 2R$  is half of its kinetic energy at  $x = R$ .

(b) Find  $c$  in terms of  $U$  and  $R$ . (3)

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4. **Figure 2**



A body consists of a uniform solid circular cylinder  $C$ , together with a uniform solid hemisphere  $H$  which is attached to  $C$ . The plane face of  $H$  coincides with the upper plane face of  $C$ , as shown in Figure 2. The cylinder  $C$  has base radius  $r$ , height  $h$  and mass  $3M$ . The mass of  $H$  is  $2M$ . The point  $O$  is the centre of the base of  $C$ .

- (a) Show that the distance of the centre of mass of the body from  $O$  is

$$\frac{14h + 3r}{20}. \quad (5)$$

The body is placed with its plane face on a rough plane which is inclined at an angle  $\alpha$  to the horizontal, where  $\tan \alpha = \frac{4}{3}$ . The plane is sufficiently rough to prevent slipping. Given that the body is on the point of toppling,

(b) find  $h$  in terms of  $r$ . (4)

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5. A light elastic string of natural length  $l$  has one end attached to a fixed point  $A$ . A particle  $P$  of mass  $m$  is attached to the other end of the string and hangs in equilibrium at the point  $O$ , where  $AO = \frac{5}{4}l$ .

(a) Find the modulus of the elasticity of the string. (2)

The particle  $P$  is then pulled down and released from rest. At time  $t$  the length of the string is  $\frac{5l}{4} + x$ .

(b) Prove that, while the string is taut,

$$\frac{d^2x}{dt^2} = -\frac{4gx}{l}. \quad (5)$$

When  $P$  is released,  $AP = \frac{7}{4}l$ . The point  $B$  is a distance  $l$  vertically below  $A$ .

(c) Find the speed of  $P$  at  $B$ . (4)

(d) Describe briefly the motion of  $P$  after it has passed through  $B$  for the first time until it next passes through  $O$ . (2)

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6. One end of a light inextensible string of length  $l$  is attached to a fixed point  $A$ . The other end is attached to a particle  $P$  of mass  $m$  which is hanging freely at rest at point  $B$ . The particle  $P$  is projected horizontally from  $B$  with speed  $\sqrt{3gl}$ . When  $AP$  makes an angle  $\theta$  with the downward vertical and the string remains taut, the tension in the string is  $T$ .

(a) Show that  $T = mg(1 + 3 \cos \theta)$ . (6)

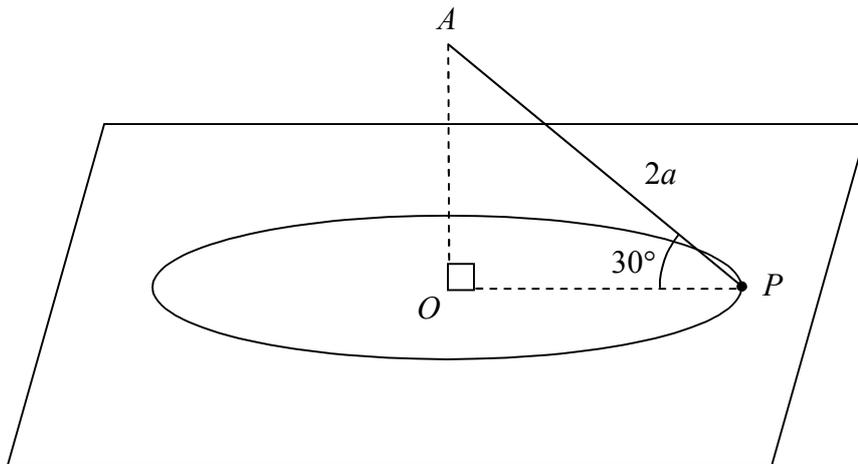
(b) Find the speed of  $P$  at the instant when the string becomes slack. (3)

(c) Find the maximum height above the level of  $B$  reached by  $P$ . (5)

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7.

Figure 3



A particle  $P$  of mass  $m$  is attached to one end of a light inextensible string of length  $2a$ . The other end of the string is fixed to a point  $A$  which is vertically above the point  $O$  on a smooth horizontal table. The particle  $P$  remains in contact with the surface of the table and moves in a circle with centre  $O$  and with angular speed  $\sqrt{\left(\frac{kg}{3a}\right)}$ , where  $k$  is a constant. Throughout the motion the string remains taut and  $\angle APO = 30^\circ$ , as shown in Figure 3.

(a) Show that the tension in the string is  $\frac{2kmg}{3}$ . (3)

(b) Find, in terms of  $m$ ,  $g$  and  $k$ , the normal reaction between  $P$  and the table. (3)

(c) Deduce the range of possible values of  $k$ . (2)

The angular speed of  $P$  is changed to  $\sqrt{\left(\frac{2g}{a}\right)}$ . The particle  $P$  now moves in a horizontal circle above the table. The centre of this circle is  $X$ .

(d) Show that  $X$  is the mid-point of  $OA$ . (7)

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**TOTAL FOR PAPER: 75 MARKS**

**END**