Paper Reference(s)

6679

Edexcel GCE

Mechanics M3

Advanced/Advanced Subsidiary

Monday 19 May 2003 – Morning

Time: 1 hour 30 minutes

Materials required for examination
Answer Book (AB16)
Mathematical Formulae (Lilac)
Graph Paper (ASG2)

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

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 $g = 9.8$ m s^{-2}.
When a calculator is used, the answer should be given to an appropriate degree of accuracy.

Information for Candidates

A booklet 'Mathematical Formulae and Statistical Tables' is provided.
Full marks may be obtained for answers to ALL questions.
This paper has seven questions.

Advice to Candidates

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. A particle P of mass m is held at a point A on a rough horizontal plane. The coefficient of friction between P and the plane is $\frac{2}{3}$. The particle is attached to one end of a light elastic string, of natural length a and modulus of elasticity $4mg$. The other end of the string is attached to a fixed point O on the plane, where $OA = \frac{3}{2}a$. The particle P is released from rest and comes to rest at a point B, where $OB < a$.

Using the work-energy principle, or otherwise, calculate the distance AB.

(6)

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2. A car moves round a bend which is banked at a constant angle of 10° to the horizontal. When the car is travelling at a constant speed of 18 m s^{-1}, there is no sideways frictional force on the car. The car is modelled as a particle moving in a horizontal circle of radius r metres.

Calculate the value of r.

(6)

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3. A toy car of mass 0.2 kg is travelling in a straight line on a horizontal floor. The car is modelled as a particle. At time $t = 0$ the car passes through a fixed point O. After t seconds the speed of the car is v m s^{-1} and the car is at a point P with $OP = x$ metres. The resultant force on the car is modelled as $\frac{1}{10}x(4 - 3x)$ N in the direction OP. The car comes to instantaneous rest when $x = 6$. Find

(*a*) an expression for v^2 in terms of x,

(7)

(*b*) the initial speed of the car.

(2)

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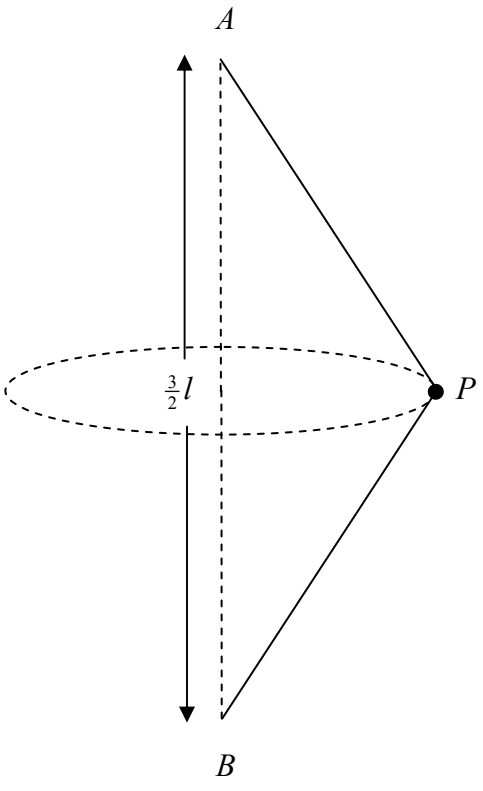
4. **Figure 1**



A particle P of mass m is attached to the ends of two light inextensible strings AP and BP each of length l. The ends A and B are attached to fixed points, with A vertically above B and $AB = \frac{3}{2}l$, as shown in Fig. 1. The particle P moves in a horizontal circle with constant angular speed ω. The centre of the circle is the mid-point of AB and both strings remain taut.

(a) Show that the tension AP is $\frac{1}{6}m(3l\omega^2 + 4g)$.

(7)

(b) Find, in terms of m, l, ω and g, an expression for the tension in BP.

(2)

(c) Deduce that $\omega^2 \geq \frac{4g}{3l}$.

(2)

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5. A particle P of mass 0.8 kg is attached to one end A of a light elastic spring OA, of natural length 60 cm and modulus of elasticity 12 N. The spring is placed on a smooth horizontal table and the end O is fixed. The particle P is pulled away from O to a point B, where OB = 85 cm, and is released from rest.

(a) Prove that the motion of P is simple harmonic with period $\frac{2\pi}{5}$ s.

(5)

(b) Find the greatest magnitude of the acceleration of P during the motion.

(2)

Two seconds after being released from rest, P passes through the point C.

(c) Find, to 2 significant figures, the speed of P as it passes through C.

(5)

(d) State the direction in which P is moving 2 s after being released.

(1)

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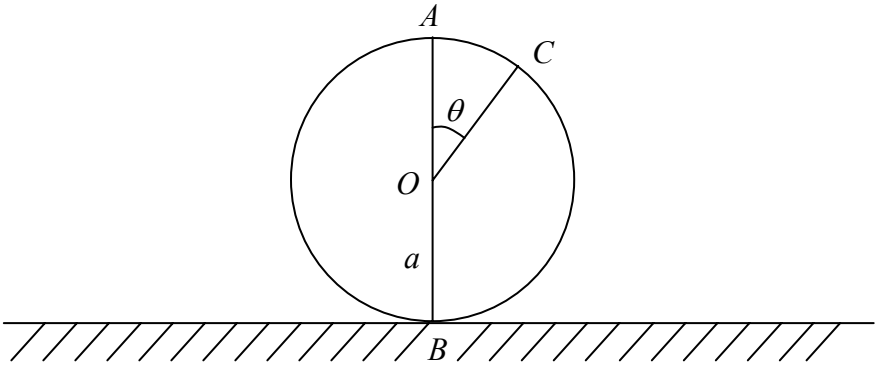
6. **Figure 2**



A particle is at the highest point A on the outer surface of a fixed smooth sphere of radius a and centre O. The lowest point B of the sphere is fixed to a horizontal plane. The particle is projected horizontally from A with speed u, where $u < \sqrt{(ag)}$. The particle leaves the sphere at the point C, where OC makes an angle θ with the upward vertical, as shown in Fig. 2.

(a) Find an expression for $\cos\theta$ in terms of u, g and a.

(7)

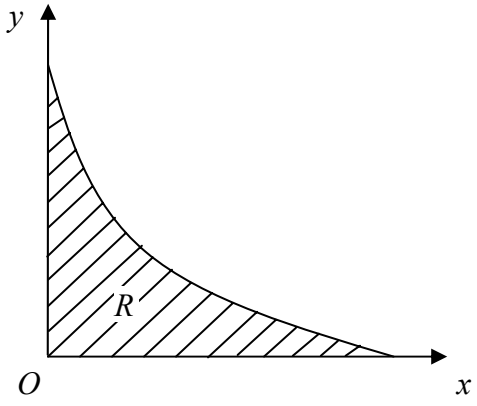
The particle strikes the plane with speed $\sqrt{\left(\frac{9ag}{2}\right)}$.

(b) Find, to the nearest degree, the value of θ.

(7)

7.

Figure 3



The shaded region R is bounded by part of the curve with equation $y = \frac{1}{2}(x - 2)^2$, the x-axis and the y-axis, as shown in Fig. 3. The unit of length on both axes is 1 cm. A uniform solid S is made by rotating R through 360° about the x-axis. Using integration,

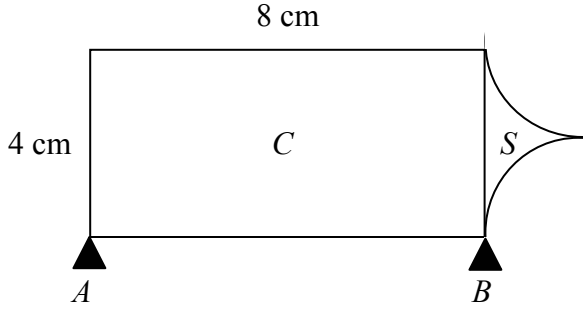
(a) calculate the volume of the solid S, leaving your answer in terms of π,

(4)

(b) show that the centre of mass of S is $\frac{1}{3}$ cm from its plane face.

(7)

Figure 4



A tool is modelled as having two components, a solid uniform cylinder C and the solid S. The diameter of C is 4 cm and the length of C is 8 cm. One end of C coincides with the plane face of S. The components are made of different materials. The weight of C is $10W$ newtons and the weight of S is $2W$ newtons. The tool lies in equilibrium with its axis of symmetry horizontal on two smooth supports A and B, which are at the ends of the cylinder, as shown in Fig. 4.

(c) Find the magnitude of the force of the support A on the tool.

(5)

END