Paper Reference(s)

6682/01

Edexcel GCE

Mechanics M6

Advanced/Advanced Subsidiary

Thursday 30 June 2005 – Morning

Time: 1 hour 30 minutes

Materials required for examination	**Items included with question papers**
Mathematical Formulae (Lilac or Green)	Nil
Answer Book (AB16)	
Graph paper (ASG2)	

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 M6), the paper reference (6682), 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

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 parts of questions are shown in round brackets: e.g. **(2)**.
This paper has 6 questions. The total mark for this paper is 75.

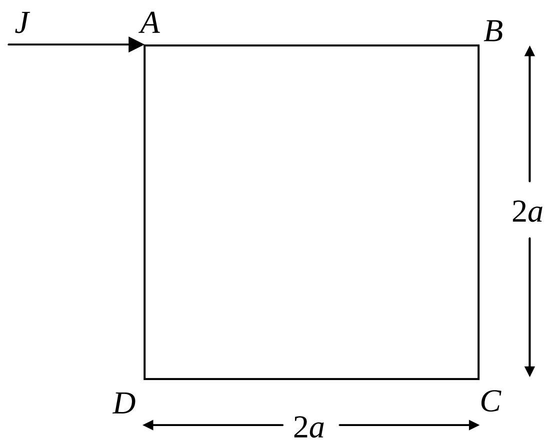
Advice to Candidates

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.

N21139A

1.

Figure 1



A square frame $ABCD$ consists of four identical uniform rods rigidly joined together at their ends. Each of the rods has mass m and length $2a$. The frame lies at rest on a smooth horizontal table. A horizontal impulse of magnitude J is applied to the frame at A in the direction AB as shown in Figure 1. The moment of inertia of the frame about an axis through its centre and perpendicular to its plane is $\dfrac{16ma^2}{3}$.

Find the speed of the mid-point of BC immediately after the impulse has been applied.

(8)

---

2. A uniform thin hollow sphere, with centre O, is released from rest on a rough plane inclined at an angle α to the horizontal. The coefficient of friction between the sphere and the plane is μ. The sphere rolls down the plane without slipping.

(*a*) Show that $\mu \geq \frac{2}{5} \tan \alpha$.

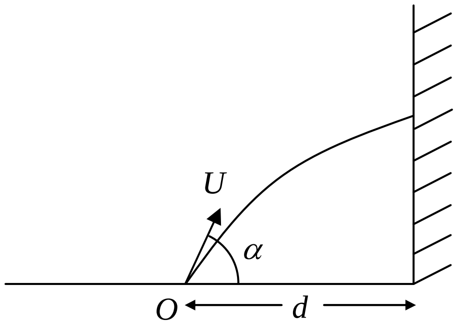
(10)

(*b*) Find the acceleration of O down the plane.

(2)

3.

Figure 2



A ball is projected with speed U at an angle α to the horizontal from a point O on horizontal ground. The ball hits a smooth vertical wall which is at a distance d from O, as shown in Figure 2. The ball moves in a vertical plane which is perpendicular to the wall and the coefficient of restitution between the ball and the wall is e. After hitting the wall, the ball hits the ground for the first time at O.

Show that

(a) the total time for the ball to travel to the wall and back to O is $\dfrac{2U\sin\alpha}{g}$,

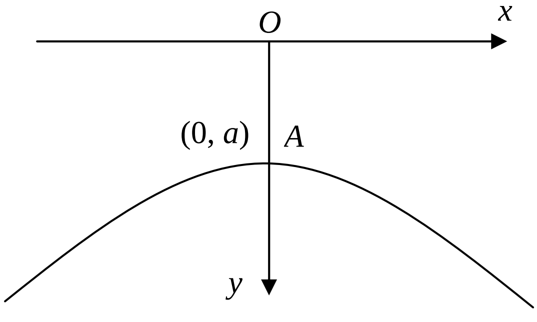
(4)

(b) $U^2 \sin 2\alpha = gd\left(1+\dfrac{1}{e}\right)$.

(8)

4.

Figure 3



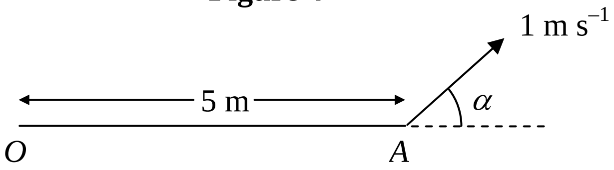
The vertical cross-section of a smooth surface is in the shape of a curve with intrinsic equation $s = a \tan \psi$, where a is a positive constant. The y-axis is vertically downwards and the highest point A of the curve has cartesian coordinates $(0, a)$, as shown in Figure 3. A particle P is released from rest from the point A and slides down the surface along the curve.

Show that P leaves the surface at the point on the curve where the tangent to the curve makes an angle $\dfrac{\pi}{3}$ with the horizontal.

(12)

---

5. **Figure 4**



A particle P of mass 2 kg moves on a smooth horizontal table. At time t, the position of P is specified by polar coordinates (r, θ) with pole O, where $OP = r$ metres and O is a fixed point on the table. The particle moves under the action of a horizontal force $\mathbf{F}$, of magnitude $\frac{10}{r^2}$ N, which is always directed towards O. When $t = 0$, P is projected from the point A, with polar coordinates (5, 0). The speed of projection is 1 m s^{-1} in a direction making an angle α with the line OA, where $\tan \alpha = \frac{4}{3}$, as shown in Figure 4.

(*a*) Show that $r^2 \frac{d\theta}{dt} = 4$.

(4)

(*b*) Find the values of r for which P is moving at right angles to $\mathbf{F}$.

(10)

---

6. A particle P of mass m moves along a plane curve with polar equation

$$r = a \sec^2 \frac{\theta}{2},$$

where a is a positive constant. The particle P moves in such a way that its transverse component of velocity, u, is constant.

(*a*) Show that the magnitude of the horizontal radial component of velocity of P has magnitude $\left| u \tan \frac{\theta}{2} \right|$.

(5)

Find, in terms of u, a and θ,

(*b*) the radial component of acceleration of P,

(4)

(*c*) the transverse component of acceleration of P.

(2)

The curve is fixed in a horizontal plane. Given that the resultant horizontal force acting on P is $\mathbf{F}$,

(*d*) show that $\mathbf{F}$ has constant magnitude,

(4)

(*e*) indicate, on a sketch, the direction of $\mathbf{F}$ when θ is acute.

(2)

TOTAL FOR PAPER: 75 MARKS

END