Paper Reference(s)

6678

Edexcel GCE

Mechanics M2

Advanced/Advanced Subsidiary

Friday 25 June 2004 – Morning

Time: 1 hour 30 minutes

Materials required for examination	Items included with question papers
Answer Book (AB16)	Nil
Mathematical Formulae (Lilac)	
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 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

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 lorry of mass 1500 kg moves along a straight horizontal road. The resistance to the motion of the lorry has magnitude 750 N and the lorry's engine is working at a rate of 36 kW.

(*a*) Find the acceleration of the lorry when its speed is 20 m s^{-1}.

(4)

The lorry comes to a hill inclined at an angle α to the horizontal, where sin $\alpha = \frac{1}{10}$. The magnitude of the resistance to motion from non-gravitational forces remains 750 N.

The lorry moves up the hill at a constant speed of 20 m s^{-1}.

(*b*) Find the rate at which the lorry's engine is now working.

(3)

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2. [*In this question* **i** *and* **j** *are perpendicular unit vectors in a horizontal plane.*]

A ball has mass 0.2 kg. It is moving with velocity (30**i**) m s^{-1} when it is struck by a bat. The bat exerts an impulse of (–4**i** + 4**j**) Ns on the ball.

Find

(*a*) the velocity of the ball immediately after the impact,

(3)

(*b*) the angle through which the ball is deflected as a result of the impact,

(2)

(*c*) the kinetic energy lost by the ball in the impact.

(4)

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3. **Figure 1**

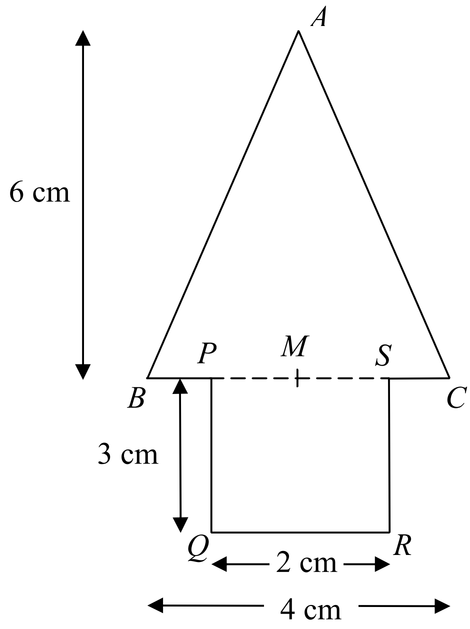

Figure 1 shows a decoration which is made by cutting the shape of a simple tree from a sheet of uniform card. The decoration consists of a triangle ABC and a rectangle $PQRS$. The points P and S lie on BC and M is the mid-point of both BC and PS. The triangle ABC is isosceles with $AB = AC$, $BC = 4$ cm, $AM = 6$ cm, $PS = 2$ cm and $PQ = 3$ cm.

(*a*) Find the distance of the centre of mass of the decoration from BC.

(5)

The decoration is suspended from Q and hangs freely.

(*b*) Find, in degrees to one decimal place, the angle between PQ and the vertical.

(4)

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4. At time t seconds, the velocity of a particle P is $[(4t - 7)\mathbf{i} - 5\mathbf{j}]$ m s^{-1}. When $t = 0$, P is at the point with position vector $(3\mathbf{i} + 5\mathbf{j})$ m relative to a fixed origin O.

(*a*) Find an expression for the position vector of P after t seconds, giving your answer in the form $(a\mathbf{i} + b\mathbf{j})$ m.

(4)

A second particle Q moves with constant velocity $(2\mathbf{i} - 3\mathbf{j})$ m s^{-1}. When $t = 0$, the position vector of Q is $(-7\mathbf{i})$ m.

(*b*) Prove that P and Q collide.

(6)

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5. Two small smooth spheres, P and Q, of equal radius, have masses $2m$ and $3m$ respectively. The sphere P is moving with speed $5u$ on a smooth horizontal table when it collides directly with Q, which is at rest on the table. The coefficient of restitution between P and Q is e.

(*a*) Show that the speed of Q immediately after the collision is $2(1 + e)u$.

(5)

After the collision, Q hits a smooth vertical wall which is at the edge of the table and perpendicular to the direction of motion of Q. The coefficient of restitution between Q and the wall is f, $0 < f \leq 1$.

(*b*) Show that, when $e = 0.4$, there is a second collision between P and Q.

(3)

Given that $e = 0.8$ and there is a second collision between P and Q,

(*c*) find the range of possible values of f.

(3)

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6. A uniform ladder AB, of mass m and length $2a$, has one end A on rough horizontal ground. The coefficient of friction between the ladder and the ground is 0.6. The other end B of the ladder rests against a smooth vertical wall.

A builder of mass $10m$ stands at the top of the ladder. To prevent the ladder from slipping, the builder's friend pushes the bottom of the ladder horizontally towards the wall with a force of magnitude P. This force acts in a direction perpendicular to the wall. The ladder rests in equilibrium in a vertical plane perpendicular to the wall and makes an angle α with the horizontal, where $\tan \alpha = \frac{3}{2}$.

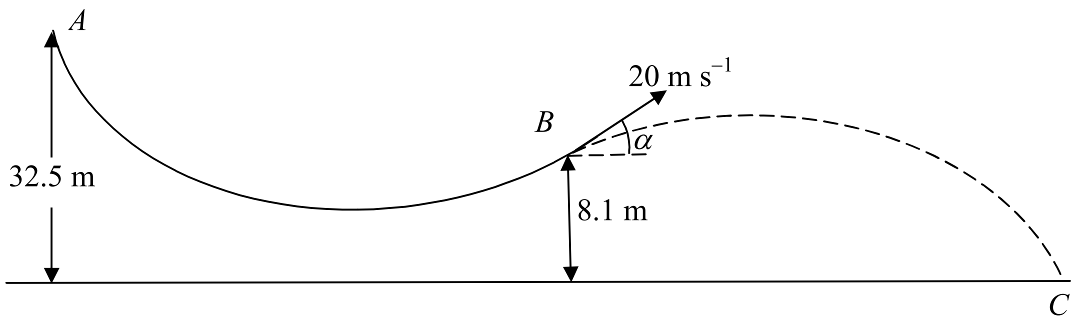
(*a*) Show that the reaction of the wall on the ladder has magnitude $7mg$.

(5)

(*b*) Find, in terms of m and g, the range of values of P for which the ladder remains in equilibrium.

(7)

7.



In a ski-jump competition, a skier of mass 80 kg moves from rest at a point A on a ski-slope. The skier's path is an arc AB. The starting point A of the slope is 32.5 m above horizontal ground. The end B of the slope is 8.1 m above the ground. When the skier reaches B, she is travelling at 20 m s^{-1}, and moving upwards at an angle α to the horizontal, where $\tan \alpha = \frac{3}{4}$, as shown in Fig. 2. The distance along the slope from A to B is 60 m. The resistance to motion while she is on the slope is modelled as a force of constant magnitude R newtons. By using the work-energy principle,

(a) find the value of R.

(5)

On reaching B, the skier then moves through the air and reaches the ground at the point C. The motion of the skier in moving from B to C is modelled as that of a particle moving freely under gravity.

(b) Find the time for the skier to move from B to C.

(5)

(c) Find the horizontal distance from B to C.

(2)

(d) Find the speed of the skier immediately before she reaches C.

(5)

END