Paper Reference(s)

6678

Edexcel GCE

Mechanics M2
(New Syllabus)
Advanced/Advanced Subsidiary
Thursday 21 June 2001 – Afternoon
Time: 1 hour 30 minutes

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

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 $g = 9.8$ 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. At time t seconds, a particle P has position vector r metres relative to a fixed origin O, where

$$\mathbf{r} = (t^2 + 2t)\mathbf{i} + (t - 2t^2)\mathbf{j}.$$

Show that the acceleration of P is constant and find its magnitude.

(5)

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2. **Figure 1**

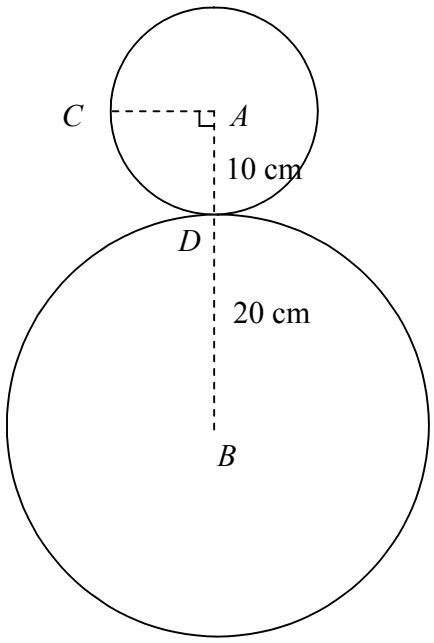

Figure 1 shows a decoration which is made by cutting 2 circular discs from a sheet of uniform card. The discs are joined so that they touch at a point D on the circumference of both discs. The discs are coplanar and have centres A and B with radii 10 cm and 20 cm respectively.

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

(5)

The point C lies on the circumference of the smaller disc and $\angle CAB$ is a right angle. The decoration is freely suspended from C and hangs in equilibrium.

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

(4)

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3. 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 0.5. The other end B of the ladder rests against a smooth vertical wall. The ladder rests in equilibrium in a vertical plane perpendicular to the wall, and makes an angle of 30° with the wall. A man of mass $5m$ stands on the ladder which remains in equilibrium. The ladder is modelled as a uniform rod and the man as a particle. The greatest possible distance of the man from A is ka.

Find the value of k.

(9)

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4. The unit vectors **i** and **j** lie in a vertical plane, **i** being horizontal and **j** vertical. A ball of mass 0.1 kg is hit by a bat which gives it an impulse of $(3.5\mathbf{i} + 3\mathbf{j})$ Ns. The velocity of the ball immediately after being hit is $(10\mathbf{i} + 25\mathbf{j})$ m s^{-1}.

(a) Find the velocity of the ball immediately before it is hit.

(3)

In the subsequent motion the ball is modelled as a particle moving freely under gravity. When it is hit the ball is 1 m above horizontal ground.

(b) Find the greatest height of the ball above the ground in the subsequent motion.

(3)

The ball is caught when it is again 1 m above the ground.

(c) Find the distance from the point where the ball is hit to the point where it is caught.

(4)

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5. A child is playing with a small model of a fire-engine of mass 0.5 kg and a straight, rigid plank. The plank is inclined at an angle α to the horizontal. The fire-engine is projected up the plank along a line of greatest slope. The non-gravitational resistance to the motion of the fire-engine is constant and has magnitude R newtons.

When $\alpha = 20°$ the fire-engine is projected with an initial speed of 5 m s^{-1} and first comes to rest after travelling 2 m.

(a) Find, to 3 significant figures, the value of R.

(7)

When $\alpha = 40°$ the fire-engine is again projected with an initial speed of 5 m s^{-1}.

(b) Find how far the fire-engine travels before first coming to rest.

(3)

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6. A particle A of mass $2m$ is moving with speed $2u$ on a smooth horizontal table. The particle collides directly with a particle B of mass $4m$ moving with speed u in the same direction as A. The coefficient of restitution between A and B is $\frac{1}{2}$.

(a) Show that the speed of B after the collision is $\frac{3}{2}u$.

(6)

(b) Find the speed of A after the collision.

(2)

Subsequently B collides directly with a particle C of mass m which is at rest on the table. The coefficient of restitution between B and C is e. Given that there are no further collisions,

(c) find the range of possible values for e.

(8)

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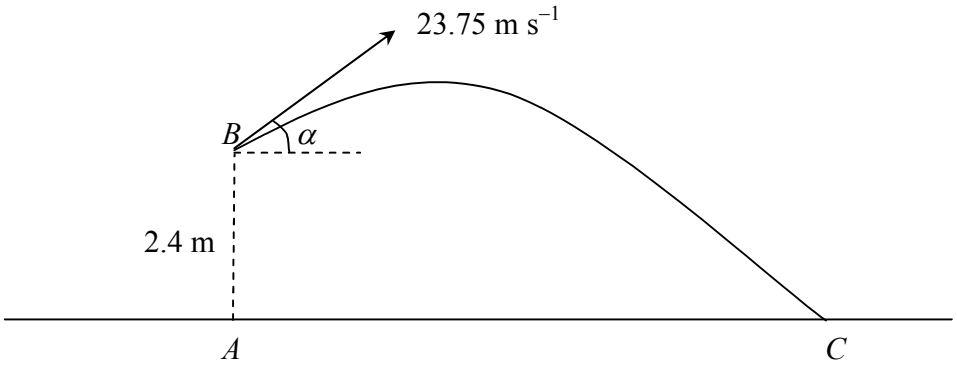
7. **Figure 2**



At time $t = 0$ a small package is projected from a point B which is 2.4 m above a point A on horizontal ground. The package is projected with speed 23.75 m s^{-1} at an angle α to the horizontal, where $\tan \alpha = \frac{4}{3}$. The package strikes the ground at the point C, as shown in Fig. 2. The package is modelled as a particle moving freely under gravity.

(a) Find the time taken for the package to reach C.

(5)

A lorry moves along the line AC, approaching A with constant speed 18 m s^{-1}. At time $t = 0$ the rear of the lorry passes A and the lorry starts to slow down. It comes to rest T seconds later. The acceleration, a m s^{-2} of the lorry at time t seconds is given by

$$a = -\tfrac{1}{4}t^2, \qquad 0 \leq t \leq T.$$

(b) Find the speed of the lorry at time t seconds.

(3)

(c) Hence show that $T = 6$.

(3)

(d) Show that when the package reaches C it is just under 10 m behind the rear of the moving lorry.

(5)

END