Paper Reference(s)

6678

Edexcel GCE

Mechanics M2
(New Syllabus)
Advanced/Advanced Subsidiary
Friday 25 January 2002 – Morning
Time: 1 hour 30 minutes

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

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. Pages 7 and 8 are blank.

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 of mass 4 kg is moving in a straight horizontal line. There is a constant resistive force of magnitude R newtons. The speed of the particle is reduced from 25 m s^{-1} to rest over a distance of 200 m.

Use the work-energy principle to calculate the value of R.

(4)

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2. A van of mass 1500 kg is driving up a straight road inclined at an angle α to the horizontal, where $\sin \alpha = \frac{1}{12}$. The resistance to motion due to non-gravitational forces is modelled as a constant force of magnitude 1000 N.

Given that initially the speed of the van is 30 m s^{-1} and that the van's engine is working at a rate of 60 kW,

(*a*) calculate the magnitude of the initial decleration of the van.

(4)

When travelling up the same hill, the rate of working of the van's engine is increased to 80 kW. Using the same model for the resistance due to non-gravitational forces,

(*b*) calculate in m s^{-1} the constant speed which can be sustained by the van at this rate of working.

(4)

(*c*) Give one reason why the use of this model for resistance may mean that your answer to part (*b*) is too high.

(1)

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3. A particle P of mass 0.3 kg is moving under the action of a single force **F** newtons. At time t seconds the velocity of P, **v** m s^{-1}, is given by

$$\mathbf{v} = 3t^2\mathbf{i} + (6t - 4)\mathbf{j}.$$

(*a*) Calculate, to 3 significant figures, the magnitude of **F** when $t = 2$.

(5)

When $t = 0$, P is at the point A. The position vector of A with respect to a fixed origin O is $(3\mathbf{i} - 4\mathbf{j})$ m. When $t = 4$, P is at the point B.

(*b*) Find the position vector of B.

(5)

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4. **Figure 1**

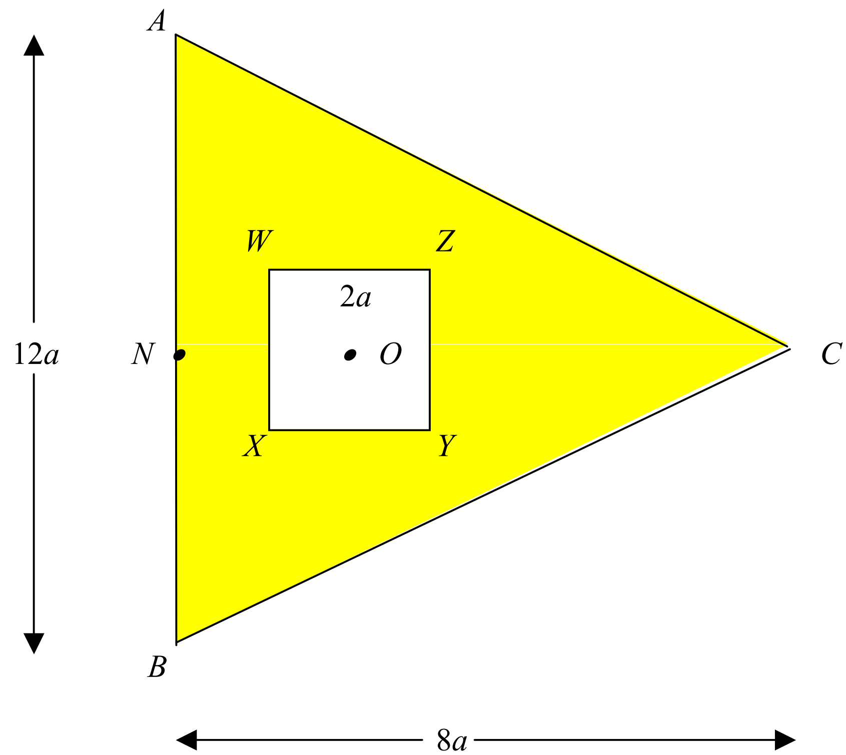


Figure 1 shows a template made by removing a square *WXYZ* from a uniform triangular lamina *ABC*. The lamina is isosceles with *CA* = *CB* and *AB* = 12*a*. The mid-point of *AB* is *N* and *NC* = 8*a*. The centre *O* of the square lies on *NC* and *ON* = 2*a*. The sides *WX* and *ZY* are parallel to *AB* and *WZ* = 2*a*. The centre of mass of the template is at *G*.

(*a*) Show that $NG = \frac{30}{11}a$.

(7)

The template has mass *M*. A small metal stud of mass *kM* is attached to the template at *C*. The centre of mass of the combined template and stud lies on *YZ*. By modelling the stud as a particle,

(*b*) calculate the value of *k*.

(4)

5. **Figure 2**

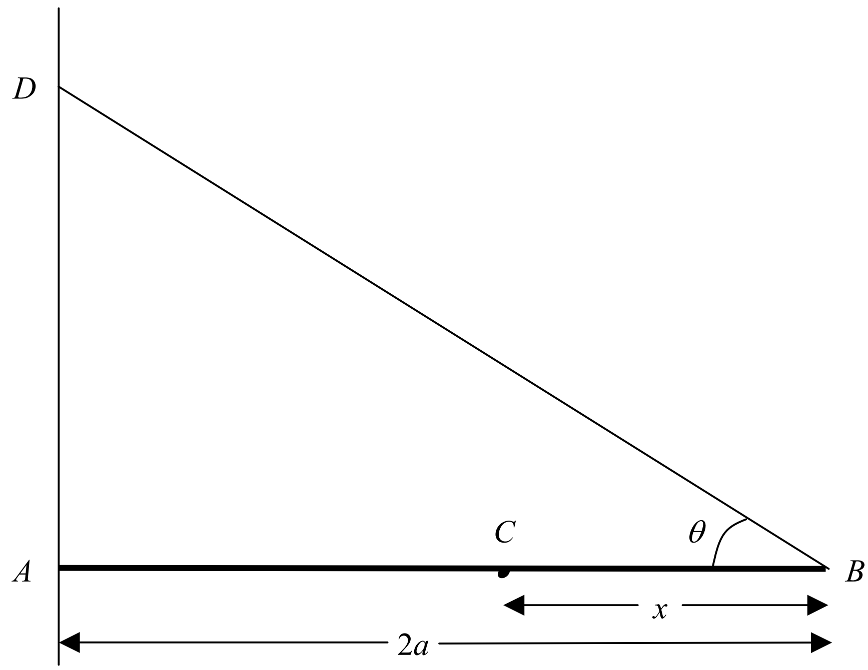


Figure 2 shows a horizontal uniform pole AB, of weight W and length $2a$. The end A of the pole rests against a rough vertical wall. One end of a light inextensible string BD is attached to the pole at B and the other end is attached to the wall at D. A particle of weight $2W$ is attached to the pole at C, where $BC = x$. The pole is in equilibrium in a vertical plane perpendicular to the wall. The string BD is inclined at an angle θ to the horizontal, where $\sin\theta = \frac{3}{5}$. The pole is modelled as a uniform rod.

(a) Show that the tension in BD is $\dfrac{5(5a-2x)}{6a}W$.

(5)

The vertical component of the force exerted by the wall on the pole is $\frac{7}{6}W$. Find

(b) x in terms of a,

(3)

(c) the horizontal component, in terms of W, of the force exerted by the wall on the pole.

(4)

6. A smooth sphere P of mass m is moving in a straight line with speed u on a smooth horizontal table. Another smooth sphere Q of mass $2m$ is at rest on the table. The sphere P collides directly with Q. After the collision the direction of motion of P is unchanged. The spheres have the same radii and the coefficient of restitution between P and Q is e. By modelling the spheres as particles,

(*a*) show that the speed of Q immediately after the collision is $\frac{1}{3}(1 + e)u$,

(5)

(*b*) find the range of possible values of e.

(4)

Given that $e = \frac{1}{4}$,

(*c*) find the loss of kinetic energy in the collision.

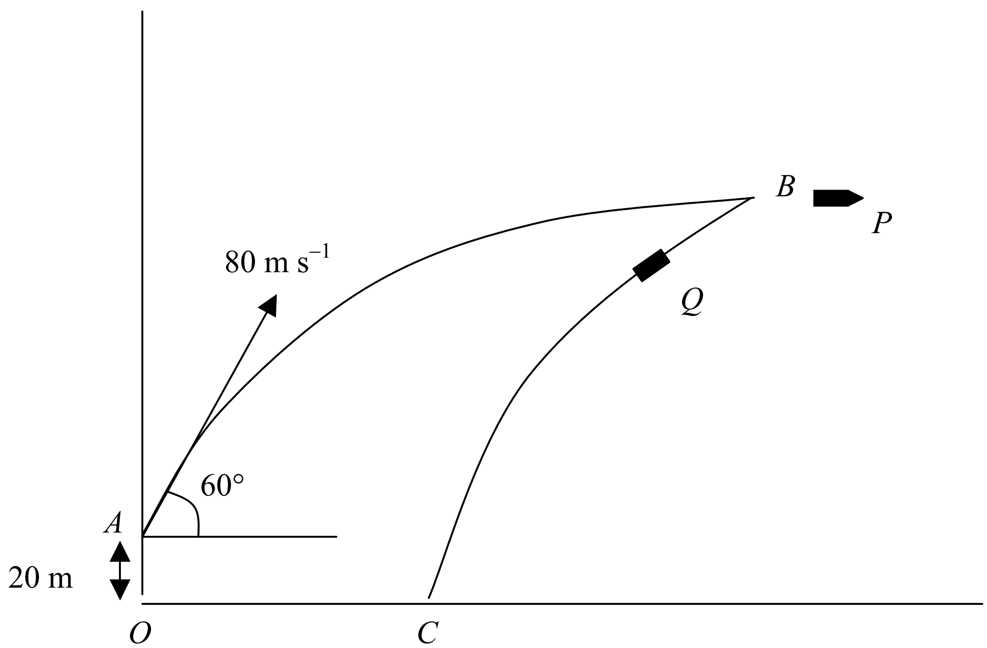
(4)

(*d*) Give one possible form of energy into which the lost kinetic energy has been transformed.

(1)

TURN OVER FOR QUESTION 7

7. **Figure 3**



A rocket R of mass 100 kg is projected from a point A with speed 80 m s^{-1} at an angle of elevation of 60°, as shown in Fig. 3. The point A is 20 m vertically above a point O which is on horizontal ground. The rocket R moves freely under gravity. At B the velocity of R is horizontal. By modelling R as a particle, find

(*a*) the height in m of B above the ground,

(4)

(*b*) the time taken for R to reach B from A.

(2)

When R is at B, there is an internal explosion and R breaks into two parts P and Q of masses 60 kg and 40 kg respectively. Immediately after the explosion the velocity of P is 80 m s^{-1} horizontally away from A. After the explosion the paths of P and Q remain in the plane OAB. Part Q strikes the ground at C. By modelling P and Q as particles,

(*c*) show that the speed of Q immediately after the explosion is 20 m s^{-1},

(3)

(*d*) find the distance OC.

(6)

END